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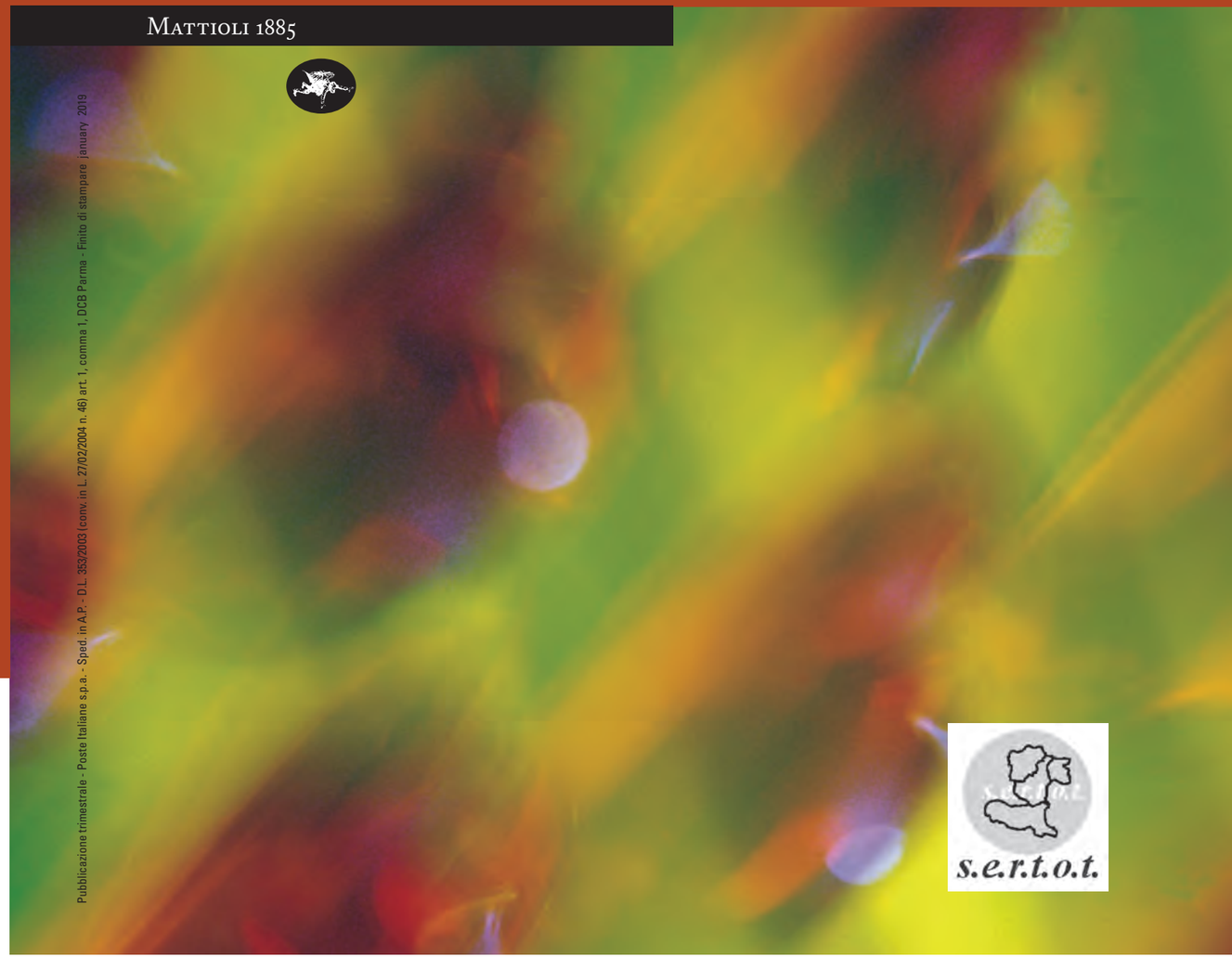

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Foreword

Dear Members,

it is with great satisfaction that I introduce the volume ACTA BIOMEDICA SUPPLEMENT 1-2019 - ADVANCES IN ORTHOPAEDICS, TRAUMATOLOGY AND REHABILITATION - SERTOT. The vitality of a Scientific Society is also assessed by its ability to regularly produce publications.

For this reason, the journal will be published in two annual issues, one dedicated to scientific papers on different orthopaedics and traumatology topics and another with unique themes.

SERTOT has always supported its own magazine, even in the most difficult moments, with qualified contributions, which in this circumstance have arrived particularly numerous, confirming how its Members and not only, while publishing in magazines of greater prestige, do not give up to scientifiwcally feed our Society and claim its future continuity.

A special thanks ... for the personal commitment and passion dedicated to the magazine.

Sincerely

Enrico Vaienti

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Review

Muscle stem cells: what's new in orthopedics?

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Summary. *Background and aim of the work:* Adult stem cells were studied as a source of potentially useful development for tissue engineering and repair techniques. The aim of this review is to clarify the actual and possible uses of muscle stem cells in orthopedics. *Methods:* A selection of studies was made to obtain a homogeneous and up to date overview on the muscle stem cells applications. *Results:* In recent years muscle was studied as a good source of adult stem cells that can differentiate into different cell lineages. Muscle stem cells are a heterogeneous population of cells, which demonstrated in vitro a great potential for the regeneration and repair of muscle, bone and cartilage tissue. Among muscle stem cells, satellite stem cells are the most known progenitor cells: they can differentiate in osteoblasts, adipocytes, chondrocytes and myocytes. *Conclusions:* Although muscle stem cells are a promising field of research, more pre-clinical studies in animal models are still needed to determine the safety and efficiency of the transplant procedures in humans. (www.actabiomedica.it)

Key words: muscle stem cells, satellite cells, muscle repair, bone healing, cartilage healing

Introduction

Stem cells can be adult stem cells or embryonic stem cells. They can be totipotent (cells capable of becoming an entire organism), pluripotent (cells capable of generating the three germ layers) and multipotent (cells of a specific germ layer becoming organ-specific progenitors). The adult stem cells have two characteristics: self-renewal and multi-lineage differentiation (1). Stem cells give tissues and organs the possibility to develop and regenerate. Biochemical and bio-mechanical signals regulate proliferation and differentiation of stem cells, typical of early development and tissue regeneration (2). There is considerable heterogeneity in the classification of Muscle Stem Cells (MSCs). The International Society of Cell and Gene Therapy (ISCT) system is still the current classifying system for MSCs (3). After birth, muscle regeneration is mediated mostly by Satellite Cells (SCs): these cells are flattened cells, located between the sarcolemma and the basal lamina of myofibers (4). They represent a heterogeneous population of self-renewable stem cells. They are quiescent in vivo, but they can be activated by increased muscle work such as after-load-induced hypertrophy, prolonged exercise, and in some pathological conditions such as myotraumas. When activated, SCs proliferate, migrate from the myofibers, and express specific myogenic markers, thus becoming muscle precursor cells (MPCs). Recent studies on Muscle Stem Cells (MSC) highlighted their possible use in repair of muscles and regeneration of tissues like bone and cartilage. MSCs can be separated in 2 subtypes CD45+ and CD45-. The first ones, if isolated by the muscle, have a limited myogenic potential but a high hematopoietic potential. The CD45- cells have a high myogenic potential and a low hematopoietic potential (5-7). Environmental signals like Wingless/Integrated 8 (Wnt8) can modify the differentiation potential of the MSCs (8).

MSCs demonstrated good transplantation behavior in animal models and resistance to in vitro manipu-

lation, becoming in this way very useful in the repair and regeneration of musculoskeletal tissues (9).

The aim of this review is to investigate the actual and possible use of muscle stem cells in musculoskeletal diseases.

MSCs and factors that regulate stem cell self-renewal and differentiation

MSCs are related with endothelial cells of the capillaries or with pericytes; some myogenic-endothelial progenitor cells are in fact CD34+ and CD45- (10). These cells can differentiate in vascular endothelial cells or musculoskeletal cells (11). Some studies demonstrated that MSCs are associated with vascular structures, particularly with the myofibers surrounding capillaries (6, 12). The hypothesis is that repair of the local skeletal muscle is made by resident stem cells (8). MDSCs cell cycle is modified and enhanced in vitro by growth factors: insulin-like growth factor-1 (IGF-1), epithelial growth factor (EGF), stem cell factor (SCF) and fibroblast growth factor-2 (FGF-2) (13).

Harvesting technique

One of the major limitations in the use of satellite cells is the low number of extracted cells due to the small size of biopsies and the difficult separation from other cellular components, it is still a challenge to obtain enough muscle stem cells in vitro. The first effort to obtain a method for dissociating mammalian muscle into intact, living single fibers was introduced by Bekoff and Betz in 1977 (14). Afterwards, Bischoff modified the Bekoff and Betz method to permit the study of SC proliferation on rat flexor digitorum brevis muscle fibers in vitro (15). Rosenblatt et al. (16) proposed a method for isolating myogenic cells based on the previous method described by Bischoff (15). This allows isolation of SCs from single muscle fibers. Cells can easily be removed from culture and analyzed. In this way, differences in myogenic cell behavior can be detected with greater sensitivity and reliability, both within and between muscles (16). Muscle stem cells can be obtained with two different approaches: single fiber isolation and whole muscle enzymatic digestion. There are different protocols to obtain these cells. An efficient protocol to isolate and expand in culture human muscle precursor cells from different skeletal muscles was described by Franzin et al. (17).

Muscle regeneration and repair

Muscle injuries usually imply a mechanism of shearing, with torn connective tissue and myofibers, or a punctiform damage. In this case only the myofibers are damaged while connective tissue does not present damage. Immediately after the trauma there is hematoma formation, muscle degeneration, necrosis and infiltration of inflammatory cells (18). After this phase there is a reparative phase, with phagocytosis of necrotic or damaged tissue, muscle fiber regeneration, formation of scar tissue and neovascularization (19). In the following remodeling phase there is muscle regeneration and reorganization of scar tissue. The MDSCs (CD45+) are involved in muscle regeneration (7). MDSCs can differentiate in myofibroblast-like cells in vitro and so can contribute to scar formation after muscle injury in vivo, mainly if stimulated with Tumor Growth Factor β-1 (TGF- beta1) (20, 21). The activation of SCs induces fibroblasts to produce extracellular matrix and proliferate (22). This extracellular matrix production in some traumas can lead to excessive scar formation with insufficient muscle regeneration (21). In these cases, some studies demonstrated that some signals can prevent formation of an over-fibrotic scar (gamma interferon, decorin) and others (IGF-1) can improve muscle healing (23-25). In any case, MSC transplantation techniques still have bad results (26). Recent studies highlighted that only a small part of the satellite cells are true muscle stem cells. This subpopulation proliferates slower than the main one (27, 28), but it is in charge of the long-term survival of implanted cells (29). Rossi et al. demonstrated how hydrogel technology can be applied to skeletal muscle for the reconstruction of damaged muscles, designing the delivery of either stem cells or muscle progenitor cells (30).

Bone healing

Fracture repair involves: acute response to damage, intra-membraneous bone formation, endochon-

dral bone formation, cartilage formation and bone remodeling (18). Different techniques were studied to repair bone defects, in particular biologically enhanced allografts, gene- or cell-based tissue engineering (31, 32). MSCs can be induced to have osteogenic differentiation and can heal bone defects in animals (18). A subpopulation of MSCs in skeletal muscle can be induced by osteogenic proteins. It was shown that murine MDSCs genetically modified to express bone morphogenetic protein- 2 (BMP-2) and BMP-4, a group of proteins of the TGF family with a pivotal role in bone remodeling, can differentiate into an osteogenic lineage, determining, in these studies, bone healing in long bones in mice models (33-38). Moreover, vascular endothelial growth factor (VEGF) modulates bone formation, improving bone healing after implantation of MDSCs with expression of BMP2 and BMP4 in animal models (39, 40). There are ongoing Clinical Trials on humans.

Articular cartilage repair

Cartilage is known to have poor healing capacity. Adult articular cartilage has no vascularization or innervation, and defects with a diameter larger than 2-4 mm usually do not heal (41, 42). Nowadays, the main operative treatments of articular cartilage defects are: total joint replacement, transplantation and articular surface debridement. The tissue repaired with transplantation does not integrate and degenerate over time (43).

Cartilage repair via chondrocyte transplantation

There are different articular cartilage repair techniques, all of them with unproven long-term efficacy in animal models (44, 45). Investigated procedures are: transplantation of cartilage plugs (46), autologous chondrocytes transplantation (44), allogenic chondrocytes transplantation (47) and fetal chondrocytes transplantation (48, 49).

Muscle-derived cells for cartilage repair

A satisfactory result was obtained in cartilage healing using muscle-derived stem cells. MSCs showed if transplanted in cartilage articular defects artificially created in rabbits a result comparable to chondrocytes transplantation (50), with the production of type-II collagen (51).

Other future promising techniques for cartilage repair

Furthermore, genetic engineering can have an important role in regenerative medicine. An adenoviral vector (with IGF-1 expression) was used to transduce and enhance equine mesenchymal stem cells (53). Cells so enhanced secreted IGF-1 stimulating changes in cartilage matrix gene expression (54), inducing cartilage healing. Other growth factors can stimulate stem cells proliferation, migration and differentiation: BMPs bone morphogenetic proteins (BMP), Transforming growth factor (TGF)-beta1, beta2 and beta3 and fibroblast growth factors (54). A better understanding of these factors could lead to a combined use of stem cells and growth factor in articular defects.

Conclusions

There are still many obstacles in the use of MSCs in regenerative medicine. Their transplantation as clinical therapy is far from being efficient (55). Some clinical studies reported the use of MSCs to treat pathologies like rotator cuff tears (56) and articular cartilage damage (57). Other fields of application were clinical trials on human cardiac disease, stress incontinence of the bladder and muscular dystrophies (58). The biological properties and effects of MSCs in vivo on musculoskeletal tissue healing remains overall not satisfactory. An obstacle to the success of myogenic stem cell therapy in humans is to obtain a sufficient number of freshly isolated satellite cells (59). Basic science studies and preclinical works are needed before the use in clinical practice in orthopedics of these techniques with an acceptable level of efficiency and safety. Recent research is focused on the clinical use of reconstructive techniques to obtain repair of tissue loss in murine models (60). The increasing knowledge of molecular mechanisms at the basis of the activation, differentiation, and phenotypic switch of the MSCs is the first step towards the comprehension of their role in muscular pathologies. The promising combination of adult

stem cell use, gene therapy techniques and tissue engineering will obtain new and effective therapies for the healing of tissues with low regenerative capacity.

Authors' contribution:
C.B. and A.C.: study concept and design; drafting of the paper;
A.C. and I.F.: literature research and data collection;
C.B. and A.P.: analysis and interpretation of data;
P.R.: final approval of the version to be published.

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Review

Single ray amputation in traumatic injury of the hand: review of literature

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Summary. *Background and aim of the work:* Ring avulsion are relatively common hand lesions and are associated with significant disability, especially in hand-workers. The treatment choice is still debatable. We sought to conduct a detailed systematic review in attempt to collate evidence on functional, cosmetic and patient-reported outcomes (PROs) following ray amputation for the management of traumatic hand injury and ring avulsion injury. *Methods:* Using the PubMed database we made a systematic search for articles regarding single ray amputation after traumatic hand lesion. Nine articles met our including criteria and were analysed. *Results:* Most of the included studies suggest that for those worse cases ray amputation still represent a good option. Indeed ray resection can eliminate the gap, remove a cumbersome or painful digit and guarantes better cosmesis but reduces grip and pinch strength (from 15% to 30%) and decreased palm width. *Conclusions:* Different surgical techniques are available, almost all of them results in a loss of strength but ensure good both functional and cosmetic results. (www.actabiomedica.it)

Key words: ray resection, ring finger injury, outcomes, grip strength, pinch strength, review

Introduction

A certain kind of finger injuries is ring avulsion injury: they usually involve only one finger (1) and happen when a ring is caught on an immobile object, from crush traumas or less common means such as thermal injury (2).

Severity of injury increases as the ring maintains traction on the skin and strips the underling tissues from the underlying skeleton. Moreover dislocation or traumatic amputation at the distal interphalangeal joint (DIPJ) and proximal phalanx fracture may also complicate the injury. Furthermore, avulsion injury also have the potential of damaging the flexor tendon sheaths and neurovascular structures (2).

These specific lesions have been classified by Urbaniak et al. in three classes (Table 1):

1) circulation adequate, 2) circulation inadequate with venous and/or artery injury, 3) complete degloving or amputation (2-5). Kay et al. modified the classification as follow: 1) circulation adequate, with or without skeletal injury, 2) circulation inadequate (arterial only or venous only), no skeletal injury, 3) circulation inadequate (arterial and venous), fracture or joint injury present, 4) complete amputation or degloving (Table 2) (2-4).

Adani et al. described a further subclassification of IV class: those with amputation proximal to the insertion of flexor digitorum superficialis fared worse than those amputated distal to its insertion (4).

The treatment of finger injuries, and in particular ring injuries, has always presented complex man-

Table 1. Urbaniak's et al. classification of ring finger injuries

I	Circulation adequate
II	Circulation inadequate with venous and/or arterial injury
III	Complete degloving or amputation

Table 2. Kay's et al. modified classification of ring finger injuries

Ia	Circulation adequate without skeletal injury
Ib	Circulation adequate with skeletal injury
II	Circulation inadequate (venous only or arterial injury) + no skeletal injury
III	Circulation inadequate (venous and arterial injury) + fracture or joint injury
IV	Complete degloving or amputation

agement problems: before the advent of microsurgery debate centred on whether distal flap coverage or grafting was preferable to amputation. In the era of microvascular repair the choices have become more complicated; alternatives include replantation and free tissue transfer in addition to local flap, pedicle flap, or graft coverage (3).

The indications for ray resection are ischemic necrosis involving the metacarpal, severe dysfunction of the proximal interphalangeal joint (PIPJ) and amputations at the level of the proximal phalanx (6, 7). Amputations performed distal to the PIPJ have good outcomes without ray resection (6, 8-10). However a stiff, obstructive finger, regardless of length, may cause decreased function and dexterity of the remainder of the hand and sometime may be painful, repeatedly traumatized and useless (6, 11). The primary contraindication to this procedure is any psychological barrier to amputation (6).

The surgical techniques include: ray resection without bony transposition, small finger-to-ring finger ray transposition, second finger-to-long finger transposition, ray transposition by intercarpal osteotomy (12). Other techniques have been described by Iselin and Peze (15) who practice an osteotomy of the carpus, or Le Viet who described a V-shaped osteotomy of the carpus proximal to the fourth metacarpal through the hamate (16).

The advantages of ray resection are gap elimination, removal of a cumbersome or painful digit, and better cosmesis (6, 13, 17). The gap caused by missing digit, especially central fingers, could jeopardize the function of the whole hand, weaken the grip strength, or result in difficulty in the control of small objects or performing skilful movements because of malalignment of the fingers close to the injured one (11, 15, 17).

Transposition of the neighboring metacarpal for a central digit amputation has been suggested to prevent gapping, scissoring, malrotation or discrepancies of digit length. It also improves function of hand as an entity (7, 11, 13).

Ray amputation of the index finger, even though disabling, is better than amputation at proximal interphalangeal (PIP) or metacarpophalangeal (MCP) level, as middle finger adapt to the role of index finger.

The main disadvantages of the procedure include decreased grip and pinch strength (from 15% to 30%), decreased palm width, and an abnormal finger count (6).

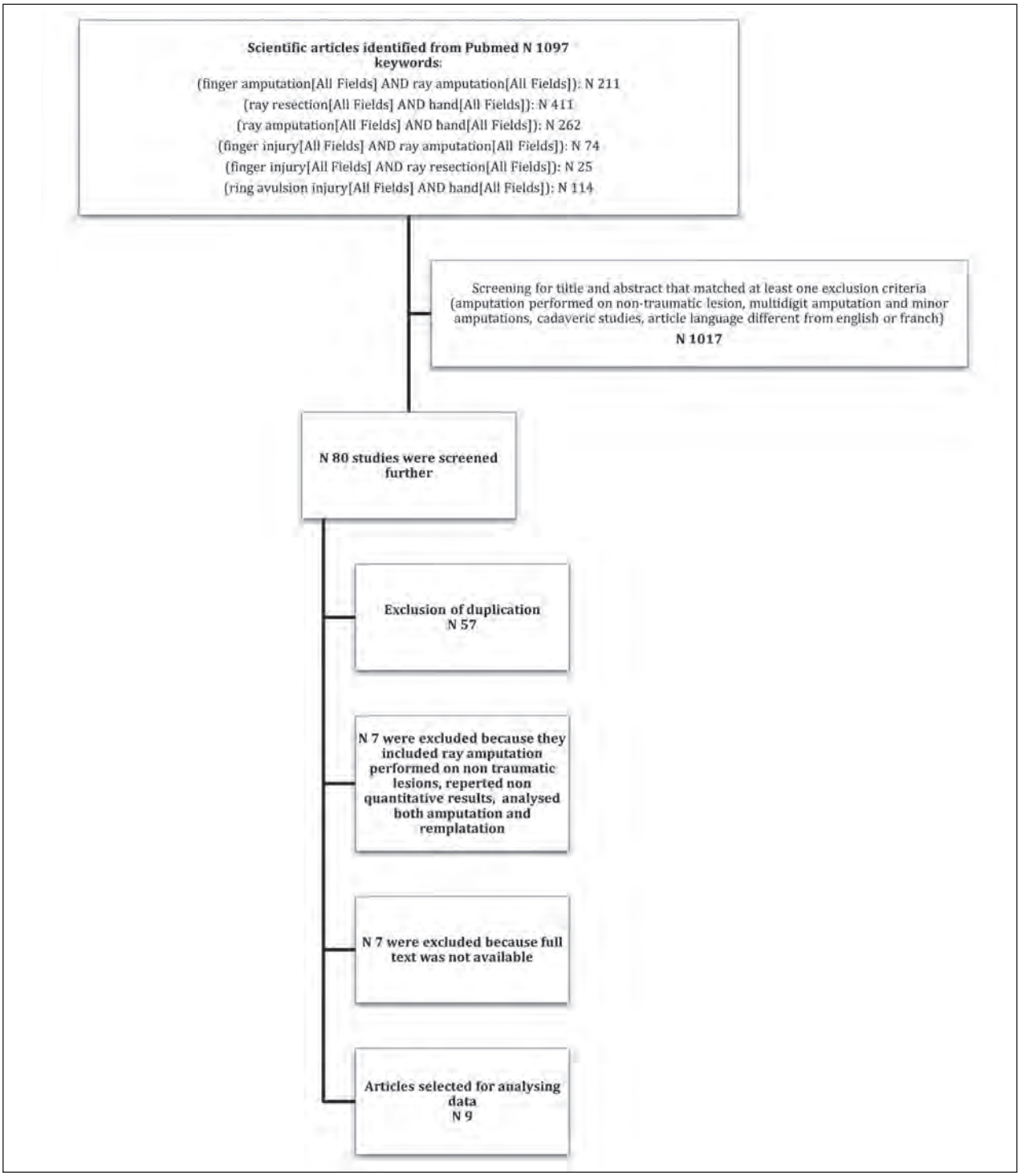
The complications that may occur are infection, cold intolerance, pain, neuroma, tenderness of the scar, tendon adhesion and joint stiffness. In those cases where bony transposition is performed non-union, pseudarthrosis or malunion may occur (2, 7, 14, 17, 18).

The aim of this study is to review the literature regarding amputation of one ray as treatment for traumatic injuries of the hand, especially ring avulsion injuries. First ray was excluded because it has different indication of treatment and it should always be tried to save the thumb. We have focused on functional and cosmetic results and patients' satisfaction to determine whether ray amputation is a good treatment choice and which are the indications.

Materials and Methods

PubMed was systematically searched from January 1970 through August 2018 to identify relevant studies. The search items were listed as the flowchart 1 shows.

First the resulting articles were screened based on the title and abstracts. Inclusion criteria were: (1) studies regarding adult patients, (2) traumatic injuries of one ray treated by ray amputation with or without metacarpal transposition (first ray injuries were excluded), (3) evaluation of functional results and patients' satisfaction, (4) French and English articles. Studies were excluded if (1) the amputation was performed on non-



Flowchart 1.

traumatic lesion, (2) multidigit amputation or first ray amputation, (3) if they analysed minor amputations such as distal or proximal phalanx amputation only, (4) cadaveric studies. The selected articles were then fully read and nine were included in this review, their results were collected and analysed (Table 3).

Table 3. Studies included in the review

Study and year of publication	Country	Kind of study	N° of cases	Male/ Female	Age	Dominant hand	Follow up (months)
Sadek 2015 (11)	Egypt	Prospective comparative study	12 Primary amputation	10/2	35±9 (19-48)	4	28±10
			13 Delayed amputation	9/4	29±16 (7-56)	5	(16-48)
Pedrazzini 2009 (13)	Italy	Case report	1	0/1	56	1	18
Segret 2008 (8)	France	Retrospective study	11	8/3	35 (16-69)	5	9 (3-19)
Nuzumlali 2003 (9)	Turkey	Retrospective study	14	8/6	33 (16-58)	9	37 (24-63)
Peimer 1999 (10)	USA	Retrospective comparative study	12 primary amputation 13 secondary amputation	18/7	28 (16-64)	14	41 (16-154)
Levy 1999 (12)	USA	Case report	1	1/0	13	1	300
Van Overstraeten 1995 (22)	France	Retrospective study	9 primary amputation 34 secondary amputation	36/7	30 (4-55)	14	40
Peze Iselin 1988 (15)	France	Retrospective study	12	/	/	/	6
Steinchen 1986 (14)	USA	Retrospective study	13	10/3	38 (16-54)	4	43 (3-93)
Mean/total			**145**	**100/33**	**37.1**	**101**	**58**

Results

Our search through PubMed selected 9 studies, two of them are case report and the others are retrospective studies or retrospective comparative studies. Altogether we could analyse the functional and cosmetic results of 145 cases of ray amputation, eighteen of them were border digit the others were central ray (Table 4). Three studies separated patients who underwent primary amputation from those who had secondary ray resection and collected their outcomes separately (Table 3). Most of the patients involved were males, the mean age was 37,1. The injured hand was the dominant in 57 cases. The minimum follow-up was 3 months and the longest was 25 years.

The most frequent surgical technique performed by the selected studies was ray resection with metacarpal transposition. Six patients needed additional surgery because of complications.

Every study measured grip strength after metacarpal resection, four reported also pinch strength and seven recorded MCPJ range of motion at the transposed ray (Table 5). Only Sadek compared supination and pronation strength of the operated arm and the healthy one. Residual pain was investigated only by Sadek and Van Overstraeten. The complications that occurred are shown in Table 7, its aerage rate is low (6%): infection, neuromas, palmar tenderness and intolerance to cold are the most frequent. Even though most of the patients said to be satisfied of the surgery

Table 4. Description of surgical technique and ray resected for each study

Study	Ray resected	Surgical technique	Revision surgery
Sadek (11)	IV	IV ray resection, transposition of V MC, fixed with K wire and reconstruction of deep transverse inermetacarpal ligament	/
Pedrazzini (13)	IV	IV ray resection, transposition of V MC, fixed with K wire and reconstruction of deep transverse inermetacarpal ligament	/
Segret (8)	IV	IV ray resection, transposition of V MC, fixed with K wire and reconstruction of deep transverse inermetacarpal ligament	20% (2 cases) intermetacarpal space too wide
Nuzumlali (9)	IV	Not described	/
Peimer (10)	III or IV (7 cases) II or V (18 cases)	Only in case of central amputation a ray transfer of border digit was done by ostetotomy	/
Levy (12)	III	Secondary ray resection without ray transposition, reconstruction of intermetacarpal ligament	/
Van Overstraeten (22)	III (19 cases) IV (24 cases)	III Metacarpal resection (6 cases), with transposition II-III (13 cases), IV metacarpal resection (16 cases), translocation IV-V according to Leviet (7 cases), classic translocation (1 cases)	/
Peze Iselin (15)	III	Ray resection, osteotomy of the hamate, reconstruction of intermetacarpal ligament	/
Steinchen (14)	III (4 cases) IV (9 cases)	Ray resection without bony transposition, reconstruction of deep transverse metacarpal ligament e dorsal dermadesis	4 (for complication)

eight of them had psychological problems in accepting a four-finger-hand. The mean time before returning to work is 3,6 months.

Discussion

According to Urbaniak classification, class I ring injuries recover very well with soft tissue treatment alone (2). Class II injuries can be successfully revascularized in almost all instances, with sensibility, strength, motion, and appearance approaching normal in the majority of patients (3). Except in those cases that present also laceration of the sublimis and profundus tendons and proximal phalanx fractures which demonstrate poor motion and cold intolerance (2,5). In contrast class III ring finger injuries present the greatest challenge both to revascularize and to achieve function and they may best be managed by primary amputation (2,3). Also Sood stated that any patients who have lost a portion of a central ray at or proximal to the midportion of the proximal phalangeal level should be considered for ray amputation and adjacent ray transposition (18).

According to Kay classification, Kay et al. found that skeletal injury is correlated with successful salvage leading to significant difference in total active motion. They also found significant difference in occurrence of complications requiring further surgery (36% in class II, 83% in class III). In class II there were no primary amputation whereas 16,7% of class III had primary amputations (3).

Many surgical techniques are available to treat class III finger injuries, and in the selected studies there is no agreement on which one is the more suitable.

Advocates of the ray resection without bony transposition feel that even though this technique re-

Table 5. Funcional results and pain evalutation (visual analogic scale=VAS). For Sadek and Peimer are reported separate data for primary amputation and secondary amputation

Study	Grip strength compared with healthy side (%)	Pinch strength compared with healthy side (%)	Preoperative MCP joint active ROM at the transposed ray (%)	Postoperative MCP joint active ROM at the transposed ray (%)	Pronation strength compared with healthy side (%)	Supination strength compared with healthy side (%)	Pre – and postoperative hand width (cm)	VAS
Sadek (11)	84±8 75±7	94±5 91±5	87±24 80±11	83±13 79±13	87±4 77+-10	76±11 71±11	8.5±0.8 7.1±1.1 8.2±1.1 7.5±0.9	0.65±1.3 0.9±1.2
Pedrazzini (13)	74.3	/	/	100	/	/	/	/
Segret (8)	70	77	/	70.58	/	/	/	/
Nuzumlali (9)	78.9	87.5	/	/	/	/	9.5±5 8.8±5	/
Peimer (10)	82.4 63.7	94.5 81	/	100	/	/	/	/
Levy (12)	85.7	/	/	/	/	/	9.0 8.25	/
Van Overstraeten (22)	65.5 (III ray)* 76.8 (IV ray)*	/	/	/	/	/	/	*
Peze Iselin (15)	66.7	/	/	100	/	/	/	/
Steinchen (14)	67 (non-dominant involved) 74 (dominant hand involved)	/	/	100	/	/	/	/

* see Table 6

sults decreased grip strength, scissoring of adjacent fingers, inability to cup small objects, and difficulty with skilled activities, it is easier to perform, has shorter recovery time and avoids potential complications (nonunion, extensor tendon adherence and loss of motion) (12, 13). They also feel that closure of the gap results in improved cosmetic appearance (13).

Some Authors advocated isolated fourth ray amputation with no fifth ray translation owing to both good functional results in the form of 68% grip power compared with the healthy side and excellent cosmetic results (12, 14, 20).

Ray resection without bony transposition is ideal for fourth ray resection, since its metacarpal is narrower than the others and gap closure using the small finger is easily accomplished because of the relatively mobile fifth carpometacarpal joint (14).

Conversely, some other authors preferred combined fourth ray amputation and fifth ray translation, achieving better functional results in the form of 94% pinch strength and 84% grip strength in comparison with the healthy side. In addition, the ROM of the MCP joint was 83° (11).

Peimer found that patients with single ray am-

Table 6. Detalied results of Van Overstraeten study according to specifical surgical technique

Van Overstraeten 1995	Impaired mobility (19 patients)	Rotational deficit (18 patients)	Intermetacarpal laxity (18 patients)	Residual pain n° Patients	Pain score % (Min-Max)	Grip strength %
Resection III ray	0° 4 cases 80% F°<15°(MP) 2 cases 20%	1/5	2/5	1/5	4.0	62.9
Resection III ray with transposition	0° 1 case 33% E°<15° (MP) 2 cases 67%	1/3	0/3	2/3	10.0 (5-15)	70
Resection IV ray	0° 4 cases 80% F°<15° (IPP) 1 case 20%	1/6	1/4	2/4	6.0 (5-7)	67.7
Resection IV ray with Leviet technique	0° 5 cases 83% F°<15° (MP) 1 case 17%	0/6	1/6	4/6	15.7 (1-45)	82.8

Table 7. Complications, cosmetic evalutation and time before return to work

Study and year of publication	Complications	Cosmetic evaluation	Time before return to work (months)
Sadek 2015	None	10 excellent, 1 good, 1 satisfectory 9 excellent, 1 good, 1 poor	/
Pedrazzini 2009	None	Satisfied	3
Segret 2008	1 phantom hand, 8 psychological problems	All satisfied	3
Nuzumlali 2003	None	All satisfied	2.3
Peimer 1999	Not mentioned	All satisfied	2.2 4
Levy 1999	None	Satisfied	1.5
Van Overstraeten 1995	2 local infections, 1 pseudoarthrosis	Excellent 65%, good 15%, fair 15%, poor 4%	2.5
Peze Iselin 1988	1 postoperative distrophy	All satisfied	/
Steinchen 1986	2 digital neuromas 1 lumbrical/interosseous adhesions, 1 scar contracture, 4 palmar tenderness, 4 intolerance to cold	All satisfied	6.7

putation and with translation of the adjacent digit showed 28% grip, 3% key pinch and 26% oppositional pinch strength loss compared to the healthy hand. Furthermore, gross hand function as measured by the Minnesota Rate of Manipulation test (Educational test Bureau, 720 Washington Avenue S. E., Minneapolis, Minnesota) and fine finger dexterity as measured by the Timed Grooved Pegboard test showed 12% and 24% loss, respectively (10).

Segret et al. (8) analysed a series of 10 patients with ring avulsion injury treated by ray resection of the metacarpal with conservation of the proximal end in emergency. They found that grip strength was 30% of grip strength of the unaffected side (range 3-70%) and the time to return to work was three months. The 80% of their patients underwent only one surgery procedure. They concluded that this treatment is a valid choice in complete amputation with proximal disarticulation or P2 or IPPJ fracture but each case has to be discussed with the patient because there may be psychological consequence (8). Also Levy suggested that the treatment has to be discussed with the patient (12).

In a study that compare functional results in patients with ring avulsion injury at the level of PIPJ treated with ray resection or amputation, Nuzumlali et al. suggest that for those patients with lesions that cannot be replanted or undergo failed replantation the choice of treatment should be determined by the patients. They advise against ray resection in patients who have occupations that require string key and chuck pinch (9).

Some authors proposed transposing the neighboring metacarpal for central digit amputation to prevent gaping, scissoring or discrepancies of digit length (17, 18), others advocated disarticulating the carpometacarpal joint to prevent the osteotomised end of the metacarpal protruding dorsally (21).

Steichen and Idler performed a central ray resection without bony transposition on 13 patients with reconstruction of the deep transverse metacarpal ligament and dorsal dermadesis which prevented rotation after gap closure. Considering ring injuries in this series the average time to return to work was 2.8 months. All patients but one were satisfied with cosmetic appearance and function of the treated hand. None of the patients had rotational malalignament produced by this technique or angular deformity. Average grip strength was 67% of that of the dominant hand and 74% of that of the nondominant hand (14). The authors also suggest that ray transposition may not be an ideal procedure in elderly people, and patients with multiple injuries of the hand where prolonged immobilization while waiting for healing of the transferred ray might result in loss of joint motion or tendon adherence (14).

The important points of the technique of central ray resection without transposition are the tight and secure reconstruction of the transverse metacarpal ligament and the dorsal dermadesis that derotates any malrotation produced by the gap closure after ray resection. Most criticism on ray resection without bony transposition has been on a cosmetic basis. In Steichen series all patients have been satisfied with the cosmetic appearance (14).

The long finger metacarpal is the largest and its removal creates a larger gap that is not as easily closed by the index finger, with its stiff carpometacarpal joint. The result is that slight angulation will occur in the index finger through its metacarpophalangeal joint and the new second web space may be somewhat wider (14).

In III ray resection, Van Overstraeten and Foucher (22) suggested translocation of the index on the third metacarpal in manual workers, whereas III ray amputation without metacarpal transposition which give better sizing and less complications, because they have better strength results. These Authors believed also that in IV ray amputation seems better to propose a translocation according to Leviet technique in any case. They also found that, as for the fourth ray resection and transposition of the fifth ray, the patients achieved superior results to the isolated fourth ray amputation (22).

Sadek et al. compared early versus delayed fourth ray amputation with fifth metacarpal translation and found better functional results in early amputations rather than delayed amputation: in the first group the found grip strength and pinch strength to be respectively 84% and 94% compared with healthy side, whereas the second group showed respectively 75% and 91% compared with the other side. They also believe that the main underlying factor favouring sudden

intervention is the early rehabilitation allowing better active ROM, grip and pinch strength, and supination/pronation strength (11).

Also Peimer et al. feel that primary amputation is preferable in shortening the total disability and improving ultimate function: average 9 total weeks out of work for primary ray resection versus average 16 weeks out of work for patients who had secondary amputation (10).

Long-term benefits of primary middle ray amputation include removal of a middle finger that is likely to function poorly and that will compromise power gripping activities of the hand, avoidance of the problems of dissociation of the ulnar and radial parts of the hand, including isolation of the thumb-index unit from the ulnar part of the hand, which results in difficulty in chuck- pinch gripping. A primary amputation will prevent problems of a gap hand and will result in a three fingered hand in which the retained fingers are optimally aligned to provide the best possible function and appearance and allow early uncompromised use of the hand (19).

The complications incidence is low in all analysed studies, the most frequent are palmar tenderness, cold intolerance, neuromas and infection. Only one case of pseudoarthosis is reported. Although almost all patients declared to be satisfied of the surgery and of the cosmetic appearance of their hand the psychological aspect is not negligible in the choice of treatment (8,9). The average time before return to work is 3,6 months.

This study was limited by the heterogeneity of available literature. Some studies analysed only amputations of border digits some others only central fingers. Several studies focused on a specific surgical technique and this hindered comparing outcomes of different studies. Also not all the studies analysed the same outcomes and most of them were collected retrospectively. Therefore it was impossible for us to perform a meta-analysis.

Conclusions

Finger injuries are complex lesions of the hand and can require different treatments. Classifying the lesion may help to decide which is the best approach. For those worse cases ray amputation still represent a good option. There are different surgical techniques; each of them has advantages and disadvantages. Almost all of them results in a certain loss of strength but ensure good both functional and cosmetic results. Although performing a primary ray resection may lead to better functional results and faster recovery with early return to work.

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Review

Outcome of cages in revision arthroplasty of the acetabulum: a systematic review

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Summary. *Background and aim of the work:* To investigate the clinical, radiological and functional outcomes of acetabular revisions with acetabular reinforcement rings and cages. *Methods:* A comprehensive literature study of international databases was performed. Inclusion criteria were cementless revisions, use of reinforcement rings, radiological and clinical follow-up, availability of full text in English, publication between January 1990 and July 2018. In a second further analysis, we selected only studies describing patients with more severe acetabular defects (AAOS 3, AAOS 4, Paprosky III). Data extracted included mean follow-up period, radiographic follow-up, functional scores, implant failures and survival rate. *Results:* We included in our review 1327 acetabular revisions described in 28 articles. The most commonly used reinforcement rings were Burch-Schneider ring, the Muller ring and the Ganz ring. Mean follow-up for all patients together was 8.8 years. Clinical or radiological signs of loosening were reported in 191 patients, 83 patients needed further acetabular revision for aseptic loosening and 41 patients received additional surgeries for septic loosening. The mean value of the Harris Hip Score reported at the last follow-up was 76.3. Nineteen articles fulfilled the criteria for further analysis about high-grade acetabular bone defects. We analyzed 649 revisions with mean follow-up period of 8.2 years. Clinical or radiological loosening was reported in 90 patients, additional acetabular revision was performed in 39 patients and 25 patients needed further surgeries for deep infection. *Conclusion:* Acetabular revisions with cages are characterized by good survival rates and functional scores with a mean follow-up period of 8 years. (www.actabiomedica.it)

Key words: revision arthroplasty, acetabulum, cage, reinforcement ring, acetabular bone defect, acetabular revision outcomes

Introduction

Total hip arthroplasty (THA) is a successful procedure to relieve pain and improve function in patients with end-stage degenerative hip joint diseases. Kurtz et al. (1,2) estimated that, in the USA, the number of THA will go beyond 50,000 per year by 2020 and will grow to 572,000 per year by 2030.

With the constant increase of THA and the increasing of life expectancy, the number of revision surgeries will rise as well and is estimated to increase by 137% by 2030 (2).

The main causes for acetabular revisions are aseptic loosening, infection, recurrent dislocations due to malposition of the components or abductor mechanism failure, periprosthetic fractures and mechanical failure of fixation (3, 4).

Acetabular revision is one of the most challenging procedures in hip arthroplasty surgery due to bone loss, poor quality of residual bone stock, poor soft tissue and migration of acetabular components (5). This loss of bone stock results from the initial disease, bone removal at the time of primary surgery and lysis caused by micromotion of prosthetic components and wear particles (6, 7).

Several reconstruction methods for acetabular revision and management of bone loss are reported in literature including: uncemented hemispherical ac-

etabular components, impaction bone grafting with cemented a polyethylene component, structural allograft, jumbo revision shells, trabecular metal components, oblong shells, acetabular reinforcement rings and cages with or without bone grafts, custom-made triflange shells, stemmed shells, and tantalum augmentation with cementless cup (3, 8, 9). The goal of all of these techniques is to provide firm fixation of the acetabular components, preservation or reconstitution of the bone stock and positioning the acetabular component in the correct anatomical position to restore the correct center of rotation (10-12).

The aim of this systematic review is to evaluate the clinical, radiological and functional outcomes of revision THAs utilizing acetabular reinforcement rings or cages.

The rationale for the use of acetabular cages is to provide mechanical stability to the acetabular construct, protect bone graft/cup/augments transmitting the load to the host bone through the cage. Usually cages are indicated in segmental bone loss involving more than half of the acetabular surface, deficit of anterior and posterior columns and pelvic discontinuity (AAOS III-IV) (9).

Materials and methods

Search strategy

A comprehensive literature search of the Medline, PubMed Database (US National Library of Medicine, National Institutes of Health), Embase and Google Scholar was performed using defined search phrases.

Headings used for the search were "Cementless Acetabular Revision", "Acetabular revision AND reinforcement ring" and "Acetabular revision AND cementless AND reinforcement rings".

This initial research included articles published between January 1990 and July 2018 evaluating clinical and radiological outcomes and failure rate of THA revisions with reinforcement rings and cages.

Inclusion criteria were: cementless revisions (between cage and host bone), acetabular revision with the use of reinforcement rings, both radiological and clinical follow-ups, and availability of the full text in English.

We excluded from our study review articles, single case report and THA revisions due to deep infection.

Studies were first screened based on the title and abstract. Full text analysis confirmed the inclusion in the review. Citations within selected papers were reviewed to identify additional studies.

In a second analysis we selected only studies about patients with more severe acetabular defects (AAOS 3, AAOS 4 and Paprosky III). AAOS 3 defects are combined cavitary and segmental defects. AAOS 4 correspond to pelvic discontinuity. Paprosky III defect included major destruction of supporting structures and acetabular rim.

We defined the failure of the acetabular component as the need for a new revision or radiological signs of loosening of the implant. The criteria for radiographic loosening included: horizontal or vertical migration bigger than 2-5 mm, a change in acetabular tilt >3°-5°, progressive radiolucent lines, breaking of screws or reinforcement rings (8, 13-17). We classified failure into septic and aseptic.

Data extraction

Data extracted from the selected studies included authors, journal and year of publication, number of included THA revisions, mean follow-up (FU), mean patient age at time of surgery, radiographic FU, postoperative functional score, implant failure and survival rate.

Results

After the exclusion of duplicates, there were a total of 679 abstracts (634 - "cementless acetabular revision"; 42 - "acetabular revision and reinforcement rings"; 3 - "acetabular revision and cementless and reinforcement rings"). 644 publications were excluded based on title and abstract and 7 more articles were excluded after analyzing the full text. Consequently, we included in our review 28 articles.

For the second analysis based on severe acetabular defect only 19 publications fulfilled the inclusion criteria.

Due to the nature of the study, all the articles were retrospective cases of THA revisions using reinforcement rings. Randomized control trials (RCTs) were not available.

All cases (All bone defects)

We analyzed 28 articles published between 1990 and 2018 that reported the outcomes of ten different kinds of reinforcement rings (Table 1). The most commonly used reinforcement rings were the Burch-Schneider ring (13 articles), the Muller ring (12 articles), and the Ganz ring (4 articles). All the other reinforcement rings (Custom-made cage, KT Plates, MRS-Titan, Murata-Chiba support ring, ZCA Reconstruction cage, Kerboull ring) were analyzed in only 1 article each except for Contour reinforcement and reconstruction rings that were described in 2 different studies.

We included in our review 1327 patients who had had acetabular revision with reinforcement rings and in 83.3% of them (1106 patients) one of the three most commonly used reinforcement rings was used.

Analyzing all the patients together, the mean follow-up period was 8.8 years (0,5-22,9) and the mean age at the time of acetabular revision was 64.5 years (26-95). Clinical or radiological signs of loosening were reported in 191 (14,4%) patients. Eighty-three (6,3%) patients needed further acetabular revision for aseptic loosening and 41 (3.1%) patients received additional surgeries for septic loosening.

The most commonly reported functional score was the Harris Hip Score (HHS) and the mean value at the time of FU was 76.3. All the authors that used the HHS for the clinical FU reported a significant increase of the score after the acetabular revision (5, 6, 8, 11, 14, 15, 18-26).

Five hundred and three patients (37.9%) had had a Muller ring placed. These patients had a mean FU period of 5.9 years, a mean age at the time of surgery of 65.3 years and a rate of loosening of 11.9%. A Burch-Schneider ring was placed in 399 patients (30%) with a mean FU period of 5.6 years, mean age of 57.3 years and a rate of loosening of 15.8%. The Ganz ring was used in 204 THA revisions (15.4%). The mean FU period was 10.3 years, the mean age at surgery was 64.1 years and the rate of loosening was 16.2% (table 2).

High-grade bone defect cases

Nineteen articles published between 1992 and 2018 fulfilled the criteria for our further analysis (table 3).

There were 649 revision THAs described with a preoperative acetabular bone defect classified as AAOS 3-4 or Paprosky IIIa-IIIb. The mean age at surgery was 66.7 years and the mean FU period was 8.2 years. Clinical or radiological loosening was reported in 90 patients with a consequently rate of loosening of 13.9%. Additional acetabular revision was performed in 39 patients (6%) and 25 (3.9%) patients needed further surgeries for deep infection.

The Burch-Schneider ring was used in 212 patients (32.7%). The mean FU period was 6,1 years and the rate of loosening was 10,4%. In 170 acetabular revisions (26.2%) a Muller ring was used. The average FU time was 7,9 years and the loosening rate was 12.4%. The Ganz ring was used in 99 THAs revisions (15.3%). The mean FU period was 11 years and the rate of loosening was 19.2% (table 4).

Only eight authors reported the Harris Hip Score at the last follow up (5, 14, 15, 18, 19, 25-27). The average HHS at the time of the last FU was 76.5.

Discussion

Our review summarize clinical, radiological and functional outcome of acetabular revisions with deficient bone stock treated with a reinforcement ring.

Acetabular revision is still one of the most challenging procedures in hip arthroplasty surgery due to bone loss, poor quality of residual bone stock, poor soft tissue and migration of acetabular components (5). Deficiency of bone stock results from the initial osteoarthritic process, bone reaming at the time of primary surgery and lysis caused by micromotion of prosthetic components and wear particles (7, 11, 22, 28).

Several surgical techniques are reported in literature for acetabular revision and the management of bone loss (3, 8, 9). More recently, cages are usually indicated in severe acetabular bone loss involving more than half of the acetabular surface , medial wall deficiency, pelvic discontinuity and when it is not pos-

Table 1

Author	Reinforcement ring	Hips (N°)	Mean FU (years)	Mean age (years)	Loosening (clinical / radiological)	Revision - Aseptic Loosening	Revision - Septic Loosening	Functional Score (mean score)	Survival rate
Beckmann [5]	Ganz	119	16 (15-18)	65 (26-90)	19	15	4	HHS 77; womuoi 64,5; sf12 PCS 32 MCS 55.9; NRS > 50% no pain	survival rate 90,1% (82,6-94,4%)
Berry [7]	Burch-Schneider	42	5 (2-11)	61,7	12	5	5	Merle d'Aubignè (pain score 3.2 to 4,8; walking score 4,4 to 5; motion score 4,2 to 5,1)	
Bohm [29]	Muller	39	4,2 (1-13)	61 (31-86)	2	1	1	X	worst-case criterion survival rate (revision\deep infection\loss to FU) 84% at 13 yers
Bohm [29]	Burch-Schneider	26	5,3 (0,5-11)	61 (31-86)	2	1	1	X	survival rate 89% at 11 years survival rate worst-case criterion (revision\deep infection\loss to FU) 83% 11 years
Bruggemann [4]	Muller	96	12 (2,3-17)	69 (40-95)	9	8	1	X	
Eggli [18]	Ganz	5	8 (4,5-10,9)	61,7 (50-72)	2	2	0	Merle d'Aubignè from 7,5 to 13.2; HHS from 33 to 73	
Eggli [18]	Muller	2	8 (4,5-10,9)	61,7 (50-72)	0	0	0	Merle D'Aubignè from 7,5 to 13.2 HHS from 33 to 73	
Gaiani [19]	Burch-Schneider	46	6 (2-10)	82 (78-85)	0	0	0	HHS from 28,2 to 82,5 (62,2-94,8) 1 severe pain, 4 moderate pain	
Garbuz [20]	Burch-Schneider	8	7,5 (5-11)	60 (32-85)	1	0	1	HHS from 29 to 73	
Gerber [17]	Ganz	50	9 (7,8-11,6)	69 (53-86)	7	3	1	Merle d'Aubignè from 11 to 16	survival rate 81% at FU survival rate 85% at 10 years for adequate reconstruction survival rate 57% at 10 years for inadequate reconstruction
Goodmann [30]	Burch-Schneider	42	4,6 (2-19)	65,2 (33-93)	9	4	2	X	76% success: no dislocation, no loosening, no revisions
Goodmann [30]	Contour	19	4,6 (2-19)	65,2 (33-93)	9	4	2	X	
Ilchmann [21]	Burch-Schneider	40	4,7 (2,3-6,9)	70 (36-81)	16	2	0	HHS 72 at last FU	
Jain [22]	Muller (22) Burch-Schneider (2)	24	2,8 (1,1-4,5)	72,7 (66,3-79,1)	1	1	0	HHS 44,2 (SD 23.3) SF36: all parameters worst than general population	
Kokubo [14]	KT Plates (34) Muller (8) Kerboull (5)	47	15,6 (10-32)	65,8 (45-85)	12	8	0	HHS from 40.9 (18-58) to 72.1 (32-92)	
Korovessis [32]	Muller	10	2,5 (1-5)	61 (31-83)	0	0	0	Mayo Clinic Hip scale: 60% good-excellent; 40% moderate-fair	
Levai [35]	Muller	28	3,1 (3-4)	66,1 (55-76)	2	2	0	Merle D'Aubignè from 9,1 to 14.9	
Levai [35]	Burch-Schneider	2	3,1 (3-4)	66,1 (55-76)	0	0	0	Merle D'Aubignè from 9,1 to 14.9	
Li [15]	custom cages	24	5,6 (2-10)	65 (54-79)	1	0	0	HHS from 36 (20-49) to 82 (60-96)	
Makinen [34]	ZCA Reconstruction Cage+ porous metal augment	22	3 (2-4,6)	70 (27-85)	3	2	0	Oxford hip score from 13,9 (2-23) to 28,7 (13-38)	loosening: patients with previous oncological resection of acetabulum survival rate 90,9% at 36 months; 75,7% at 55 months
Murali Krishnan [11]	Contour reinforcement ring (23) Contour reconstruction ring (22)	45	7,1 (3,5-8,8)	75,6 (31-95)	2	0	3	HHS: 16 excellent-good, 6 fair, 4 poor	
Ochs [23]	Burch-Schneider	79	2,6 (1,2-4,2)	71,2 (46-90)	20	0	0	HHS 70,4 (1,5-97,1)	
Panski [28]	Muller	11	3,3 (0,5-7)	61,3 (42-86)	1	1	0	9 patients satisfied at FU	
Rosson [6]	Muller	46	5 (2-10)	63 (32-79)	10	5	0	HHS 87 (61-100) at FU	
Rosson [6]	Burch-Schneider	20	5 (2-10)	62 (22-73)	0	0	0	HHS 81 (56-99)	
Schatzker [24]	Muller	57	8,3	62,9	9	8	1	HHS from 42,7 to 84,8 SF36 40 physical e 56 mental	survival rate 92,3% at 10 years
Schatzker [24]	Burch-Schneider	38	6,6	66,8	2	0 (2 awaiting revision)	0	HHS from 45,9 to 82,8 SF36 physical 41, mental 54	survival rate 91,7% at 10 years
Schlegel [27]	Muller	109	6 (2-17)	69 (29-92)	12	6	7	HHS 70 (20-100) at FU 52% HHS<70 poor score Merle d'Aubignè 7 (0-12)	survival rate 95% at 5 years, 90% at 8 years aseptic survival rate 98% at 5 years, 95% at 8 years
Schmolders [25]	MRS-Titan	39	2,6 (1-4,3)	67 (43-88)	6	1	5	HHS from 27 (13-41) to 76 (61-91)	survival rate 84% al FU
Stockl [33]	Muller	49	6,4 (5,9-9)	67,8 (43,5-84)	8	2	2	30% no support for walking 59% mild pain	survival rate 92,9% at FU
Uchiyama [12]	Ganz	30	8 (3-17,8)	60,8 (41-80)	5	0	0	X	survival rate 96% at 5 years, 80,2% at 10 years
van der Linde [16]	Burch-Schneider	16	11,7 (6,8-16,2)	67,4 (37-83)	1	0	1	Merle d'Aubignè from 9,8 to 14,4	
van del Linde [16]	Muller	26	9,2 (6,4-13,2)	67,7 (45-87)	3	1	2	Merle d'Aubignè from 9,5 to 14	
Winter [26]	Burch-Schneider	38	7,3 (4,2-9,4)	76 (49-83)	0	0	0	HHS 82,6 (58,2-94,9)	survival rate 100% at FU
Yoshino [8]	Murata-Chiba support ring	33	17,6 (15-22,9)	54,1 (42,9-65,3)	5	1	2 (resection Arthroplasty)	HHS from 44,3 (7.79) to 77,2 (55-97)	survival rate 90,6% at 15 years (100% AAOS I-II; 97,6% AAOS III)

Table 2

Reinforcement ring	Hips (N°)	Mean FU (years)	Mean age (years)	Loosening (clinical / radiological)	Revision - Aseptic Loosening	Revision - Septic Loosening
Ganz (4)	204	10,3	64,1	33	20	5
Burch-Schneider (13)	399	5,6	57,3	63	12	10
Contour (2)	64	5,85	70,4	11	4	5
Custom Cages (1)	24	5,6	65	1	0	0
KT Plates (1)	34	15,6	65,8	5	3	0
MRS-Titan (1)	39	2,6	67	6	1	5
Muller (12)	503	5,9	65,3	60	36	14
Murata-Chiba support ring (1)	33	17,6	54,1	5	1	2
ZCA Reconstruction Cage (1)	22	3	70	3	2	0
Kerboull (1)	5	15,6	65,8	4	4	0
TOTAL	**1327**	**8,8 (0,5-22,9)**	**64,5 (26-95)**	**191**	**83**	**41**

Table 3

Author	Reinforcement ring	Hips (N°) AAOS 3-4 / Paprosky IIIa-IIIb	Mean FU (years)	Mean age (years)	Loosening (clinical / radiological)	Revision - Aseptic Loosening	Revision - Septic Loosening	Functional Score
Beckmann [5]	Ganz	68	16 (15-18)	65 (26-90)	12	X	X	HHS 77; womuoi 64,5; sf12 PCS 32 MCS 55.9; NRS > 50% non dolore
Berry [7]	Burch-Schneider	42	5 (2-11)	61,7	12	5	5	Merle d'Aubignè (pain score 3.2 to 4,8; walking score 4,4 to 5; motion score 4,2 to 5,1)
Bohm [29]	Muller	14	4,2 (1-13)	61 (31-86)	1	1	0	X
Bohm [29]	Burch-Schneider	20	5,3 (0,5-11)	61 (31-86)	1	1	0	X
Bruggemann [4]	Muller	32	12 (2,3-17)	69 (40-95)	1	1	0	X
Eggli [18]	Ganz	5	8 (4,5-10,9)	61,7 (50-72)	2	2	0	Merle D'Aubignè from 7,5 to 13.2 HHS from 33 to 73
Eggli [18]	Muller	2	8 (4,5-10,9)	61,7 (50-72)	0	0	0	Merle D'Aubignè from 7,5 to 13.2 HHS from 33 to 73
Gaiani [19]	Burch-Schneider	46	6 (2-10)	82 (78-85)	0	0	0	HHS from 28,2 to 82,5 (62,2-94,8)
Garbuz [20]	Burch-Schneider	8	7,5 (5-11)	60 (32-85)	1	0	1	X
Gerber [17]	Ganz	26	9 (7,8-11,6)	69 (53-86)	5	3	1	Merle d'Aubignè from 11 to 16
Goodmann [30]	Burch-Schneider	35	4,6 (2-19)	65,2 (33-93)	8	3	2	X
Goodmann [30]	Contour	13	4,6 (2-19)	65,2 (33-93)	9	4	2	X
Kokubo [14]	KT Plates (34) Muller (8) Kerboull (5)	47	15,6 (10-32)	65,8 (45-85)	12	8	0	HHS from 40.9 (18-58) to 72.1 (32-92)
Levai [35]	Muller	6	3,1 (3-4)	66,1 (55-76)	1	1	0	X
Levai [35]	Burch-Schneider	2	3,1 (3-4)	66,1 (55-76)	0	0	0	X
Li [15]	Custom Cages	24	5,6 (2-10)	65 (54-79)	1	0	0	HHS from 36 (20-49) to 82 (60-96)
Makinen [34]	ZCA Reconstruction Cage+ porous metal augment	22	3 (2-4,6)	70 (27-85)	3	2	0	Oxford hip score from 13,9 (2-23) to 28,7 (13-38)
Murali Krishnan [1	Contour reinforcement ring (13) Contour reconstruction ring (18)	31	8 (3,5-8,8)	75,6 (31-95)	0	0	0	X
Rosson [6]	Muller	1	5 (2-10)	63 (32-79)	1	1	0	X
Rosson [6]	Burch-Schneider	15	5 (2-10)	62 (22-73)	0	0	0	X
Schlegel [27]	Muller	100	6 (2-17)	69 (29-92)	12	6	7	HHS 70 (20-100) at FU 52% HHS<70 poor score Merle d'Aubignè 7 (0-12)
Schmolders [25]	MRS-Titan	39	2,6 (2-4,3)	67 (43-88)	6	1	5	HHS from 27 (13-41) to 76 (61-91)
van der Linde [16]	Burch-Schneider	6	11,2 (8,5-13,9)	61 (37-77)	0	0	0	Merle d'Aubignè from 9,8 to 16
van del Linde [16]	Muller	7	9,7 (8,3-13,2)	65 (51-78)	2	0	2	Merle d'Aubignè from 8,6 to 13,4
Winter [26]	Burch-Schneider	38	7,3 (4,2-9,4)	76 (49-83)	0	0	0	HHS 82,6 (58,2-94,9)

sible to achieve primary stability with hemispherical cemented or uncemented cups (16). The rationale for the use of cages is to obtain mechanical stability to the prosthetic acetabulum and to protect the allograft or the augments transmitting the load through the cage to the pelvic host bone (9, 15, 18, 21). Two main kinds

Table 4

Reinforcement ring	Hips (N°) AAOS 3-4 / Paprosky IIIa-IIIb	Mean FU (years)	Mean age (years)	Loosening (clinical / radiological)	Revision - Aseptic Loosening
Burch-Schneider (9)	212	6,1	66,1	22	9
Contour (2)	44	6,3	70,4	9	4
Custom Cages (1)	24	5,6	65	1	0
Ganz (3)	99	11	65,2	19	5
KT Plates (1)	34	15,6	65,8	5	3
MRS-Titan (1)	39	2,6	67	6	1
Muller (8)	170	7,9	65,1	21	11
Kerboull (1)	5	15,6	65,8	4	4
ZCA Reconstruction Cage (1)	22	3	70	3	2
TOTAL	**649**	**8,2**	**66,7**	**90**	**39**

of acetabular cages are described in literature: antiprotrusio cages and acetabular roof rings. The antiprotrusio cages are characterized by double flanges for the ilium and the ischium. Whereas, acetabular roof rings may or may not have a hook for cotyloid notches and usually do not have flanges for the ilium (9). Van der Linde et al. (16) reported that the only absolute indication for antiprotusio cages is pelvic discontinuity while for other acetabular defects the selection of the reinforcement rings depends on which fit best in the acetabulum. Other authors (6, 12, 29, 30) instead, underline that in the presence of segmental medial defects acetabular roof rings are insufficient to guarantee mechanical stability to the construct.

Obtaining the proper anatomical position of the socket is fundamental to re-establish the right center of rotation of the hip, but can be challenging in acetabular revision in cases with severe bone loss. Shutzer and Harris (31) in 1994 suggested high placement of the acetabulum to obtain sufficient contact between the prosthesis and the host bone. Instead, several more recent articles reported a higher incidence of acetabular loosening in these cases (11, 12, 15, 18-21, 24,25, 32, 33). In these cases, the use of graft and reinforcement rings to reestablish the right center of rotation is strongly suggested.

In our review we analyzed 1327 acetabular revisions reported in 28 articles with a mean follow-up of 8.8 years. Clinical or radiological sign of loosening was present in 14.4% of cases and 6.3% of patients underwent further acetabular revision for aseptic loosening. The most commonly reported functional score was the Harris Hip Score (HHS) and the mean value at the time of FU was 76.3 (poor results were considered to be inferior to 70 points). All the authors that used the HHS for the clinical FU reported a significant increase of the score after the acetabular revision (6, 8, 10, 11, 14, 15, 18-27). In our further analysis, we considered only acetabular revisions with high-grade bone defect. We did not encounter significant differences in the loosening rate and the need of further acetabular revision between the "all defect group" and the "high-grade defect group". In both groups, the Ganz ring was characterized by a higher loosening rate.

Recently, newer porous metal implants have been introduced. Their advantages are porous surfaces, lower modulus of elasticity and higher coefficients of friction. All of these characteristics are thought to increase and accelerate bone ingrowth. Trabecular metal hemispherical cup and augments could be an alternative solution to cages in high grade bone defect acetabular revision (34). Beckmann et al. (10], in their review, re-

ported a lower loosening rate of trabecular metal cups compared with acetabular cages. The authors strongly suggest the use of trabecular metal cups also in high-grade bone defect acetabular revision. However, long-term results are not yet available in literature.

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Is it still current to talk about first ray hypermobility?

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Summary. Since the time of D. Morton in clinical evaluation we talked about the concept of hypermobility as a cause of diseases such as hallux valgus. To date, this concept has been deepened in order to better understand the pathological mechanisms that create deformity, in order to identify the most appropriate prevention and correction procedures. Physics introduced the concept of stiffness, a property that also belongs to the podalic structures. Changing the terminology is difficult, but the knowledge of biomechanics requires the elimination of the term hypermobility because it resultsinconsistent with the physics applied to the foot, in favor of the terms stiffness and compliance. These clarifications make it possible to us to deepen even more specific and timely therapeutic choices, thus reducing the risk of iatrogenic complications which follows interventions on the first ray. (www.actabiomedica.it)

Key words: first ray, hypermobility, stiffness

In the clinical setting since D.Morton, 1935, we talked about the concept of hypermobility as a cause of hallux valgus. To date this concept has been investigated to better understand the pathomechanic that produced deformity, and to plan the best preventive and corrective procedures. Phisics introduced the concept of stiffness, a property that also belongs to the structures of the foot. It is difficult change the terminology, but the knowledge of the biomechanics of the foot requires the removal of the term hypermobility because it's inconsistent with phisics applied to the foot, in favour of the terms stiffness and compliance.

During deambulation the forefoot must be enough flexible in order to absorb the ground reaction forces but also stiff enough to support weightbearing and to shift the center of gravity forward during gait. The first ray consists of the first metatarsal and medial cuneiform as osseus components, and it's considered the most important ray in the biomechanics of the foot. Motion of first ray has long been recognized as an important component in the overall function of the foot during gait, indeed there are more references about the pathologies of first ray. One of the most common condition is the increased mobility in dorsiflexion of the first ray during the ankle rocker, defined as the condition of hypermobility, from Greek, "hyper", usually implying excess and "mobile" meaning " capable of moving or being moved readily" (1). In 1935, Dundely Morton was the first to describe the condition of hypermobility of the first ray as "…the plantar ligaments of the first metatarsal segment in these feet were lax when the other ligaments had become tense under body weight; hence the first metatrsal still retained a margin of dorsal extension and therefore was ineffective as a weightbearing structure."(2) Inducing a overweight to the lateral metatarsal (Fig 1-2). Other authors have defined in different way the condition of first ray hypermobility. In 1977, M. Root et al (3-4) defined hypermobility as "a state of abnormal first ray instability that occurs while the forefoot is bearing weight.: while forefoot is bearing weight during forefoot rocker and it's the result to attempt the first metatarsal head while hindfoot pronated".

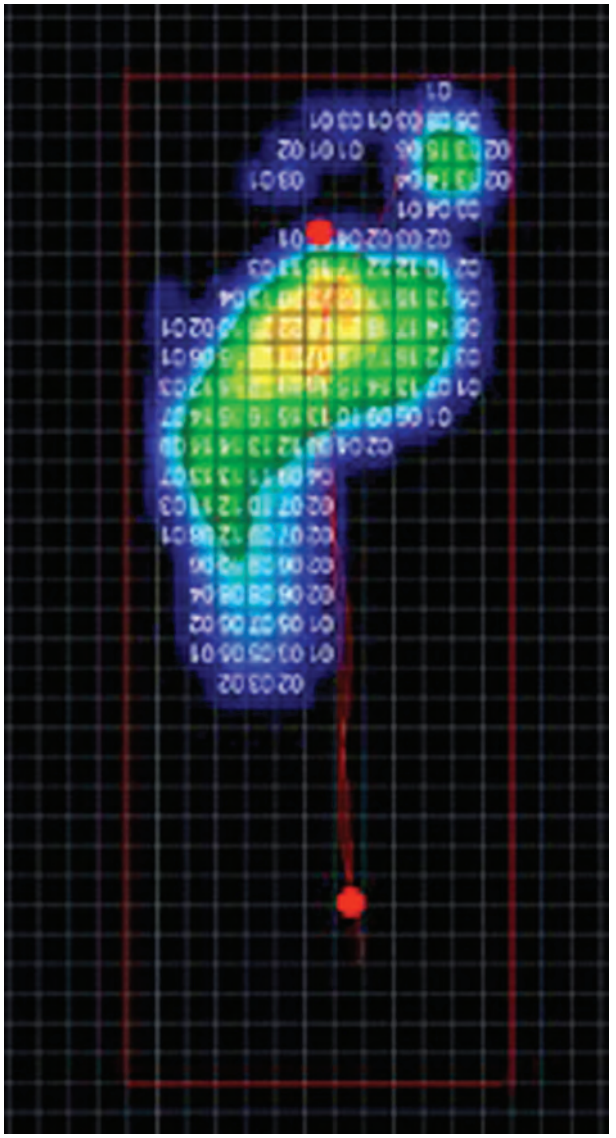

Figure 1. This image show the overload in central metatarsal head produced by recrewased indorsiflexion stiffness

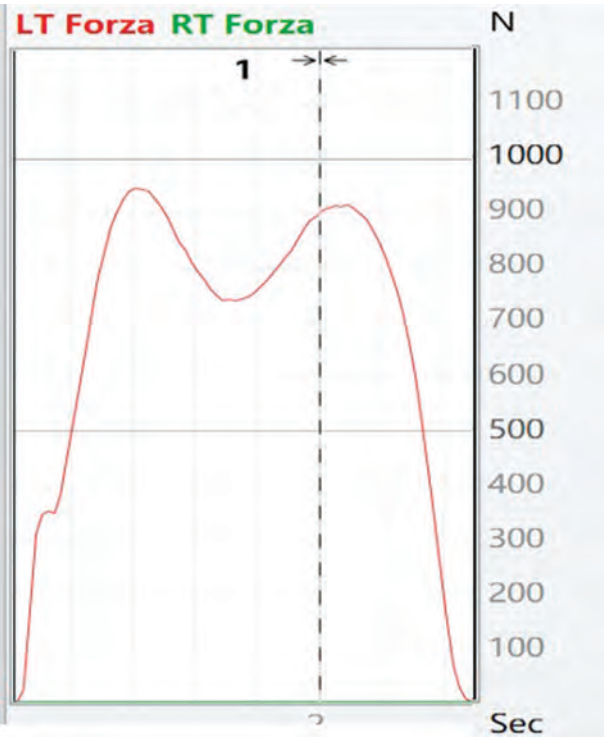

Figure 2. Butterfly of one step

Root et al attributed to excessive of pronation of subtalar joint and to the resulting grades of eversion of rearfoot, the cause of first ray hypermobility. Nevertheless this condition is one of the most frequent cause of pathomechanic of the first ray and conseguent first metatharsophalangeal pathomechanic because it produces, according to Root et al (3), inversion and dorsiflexion of the first ray, which are responsible of the subluxation of the first methatarsophalangeal joint, (hallux limitus and halux abductus valgus) and the lateral rays and metatarsophalangeal joints. The first clinical evaluation of hypermobility was described by Root et al. (3-5). It consisted in placing subtalar joint in its neutral position (which STJ is neither pronated nor supinated with midtarsal joint fully loaded along longitudinal axis) while first hand stabilizes the second through fifth metatrsal heads and the on the other hand stabilizes the first metatarsal head. In this position, the first metatarsal head is brought into full dorsiflexion and full plantarflexion; the range of motion in both directions is determined by comparing the position of the examiners fingernails dorsally and thumb nails plantarly. McInnes and Bouché (6) used Root et al's test to define the position of the first ray:1) parallel: the first and the second metatarsal heads have a "level" starting position and equal dorsiflexory and plantarflexory excursion; 2) elevated: the first metatarsal's starting position is higher than the second and it is able to dorsiflex to or above the dorsal aspect of the second metatarsal, 3) plantarflexed: the first metatarsal's starting position is lower than the second and is unable to dorsiflex past the plantar aspect of the second metatatrsal. Roukis et al (6) preferred tecnique to assess first ray mobility consist in placing the ankle

and subtalr joint in their neutral position, while stabilizing with one hand the second through fifth metatarsal heads as the other hand stabilizes the first metatarsal head. The hallux is fully dorsiflexed at the first metatarsophalangeal joint and a dorsally and plantarly directed force is applied to the first metatarsal head. The resultant dorsal and plantar first ray motion as determined by this so-called "Dynamic Hicks test" is then compared with the available first ray motion, as determined through root et al's first ray clinical mobility test.

This clinical evaluation of hypermobility in open kinetic chain is not reliable, because the hypermobility is a condition that is verificated during stance and gait. Today the scientific research, as reported by K.A. Kirby and T. Roukis (1), has introduced the new term "stiffness to descrie the ability of a structure to resist changes in shape; stiffness is defined as the amount of force required to produce a given amount of deformation or the amount of stress within a material required to produce a given amount of strain in that material, generally in Newtons per meter (N/m); Compliance wich is the inverse of stiffness is defined as the amount of deformation produced by a given amount of force and is generally described in units of meters per Newton (m/N). Using the term hypermobility during stance phase of the gait to describe the force that produces movement is misleading and imprecise." Thus it is better to define the hypermobility condition as a decrease in first ray dorsiflxion stiffness. Therefore dorsiflexion stiffness is defined as amount of force on the plantar first metatarsal head required to produce an amount of movement in dorsiflexion of the first ray. in presence of a decrease stiffness in first ray dorsiflexion, the first metatarsal head will be unable to accept its normal share of GRF in forefoot an so it will produce an increased dorsiflexion movement of the first ray and an overload on second metatarsal head. Every single ray has its own stiffness, and the biomechanic of the forefoot depends on the resultant of the sum of single rays stiffness. This property is influenced by all biomechanics of the foot, from the moment of pronation of Subtalar and midtarsal joint, and even from internal forces of muscles and ligaments; just think about the action of peroneus longus as stabilizer during platarflexion of the first ray or about the action of hallux longus flexor or hallux brevis flexor, or hallux abductur which produce a moment of plantarflexion of the first metatarsal. In 1999, Benno Nigg (7) described the changes in amplitutede of GRF on the first metatarsal head during gait produced by variations of the dorsiflexion stiffness of the first ray; these forces indeed produce a displacement of CoP [CoP is defined as the point location of the center of all the forces acting on the plantar foot (7)] toward the plantar zone of the foot. Then Eric Fuller (8) pointed out that when GRF increase on the first metatrsal head, a medial displacement of the CoP toward first metatarsal head occur, whereas instead if GRF decrease on the first metatrsal head, CoP displacement occurs lateral to the first metatrsal head. This produces an abnormal biomechanic of forefoot leading to a further pronated or supinated moment of the foot. Then, summing up, the decreased dorsiflexion stiffness of the first ray shifts Cop laterally respect to the first metatarsal head and produced an increased of pronated moment of subtalar joint or reduced supinator moment of subtalar joint, according to the axis of the joint. In case of increased dorsiflexion stiffness of the first ray, CoP displacements medially to the first metatarsal head, thus increasing the supinator moment of SBJ or decreasing the pronator moment, always according to the axis of the joint.

Conclusions

The concept of hypermobility has been ingrained in our professional terminology since many years, but the technology and the increasingly detailed study of the forces acting on the foot during stance, gait or sport activities , led us to a more accurate definition of phisiological and patological conditions of the foot. These knowledges allow us to deepen the therapeutic choises, which are getting more and more specific and timely, and to reduce the risk of iatrogenic complications which follow interventions on the first ray.

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Original article

Rotator cuff tears reparability index based on pre-operative MRI: our experience

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Summary. *Background and aim of the work:* It is recognised that a significant percetage of large and massive rotator cuff tears (RCT) cannot be anatomically repaired and this correlates with a worste outcome in terms of pain, active range of motion, increased incidence of retair. The aim of our work is to find reliable index on pre-operative MRI shoulder image to assist orthopaedist in surgical planning of rotatator cuff tears repair. *Methods:* We performed a retrospective study on a population on 131 patients undergoing arthroscopic cuff repair by a single expert surgeon. Pre-operative MRI images were evaluated by a single orthopaedist, trained on MRI shoulder images ad blinded to surgical outcome. For each magnetic resonance we evaluated the following 9 parameters: fatty Infiltration (FI), Patte Stage (PS), tear size measured in medial-lateral (ML) and anterior-posterior (AP) dimension, Tangent Sign (TS), Occupation Grade (OG), Acromion-Humeral Distance (AHD), Inferior Gleno-Humeral Distance (IGHD), Glenoid Version Angle (GVA). We divided population into two groups: patients who obtained a complete repair of RCT (n=110) and patients who obtained only a partial repair of RCT (n=21). For each MRI index we conducted statistical analysis (Student's t test, Mann-Whitney U test, Shapiro-Wilk test, Chi-square test, Fisher exact test, ROC curves and maximum Youden index) to find a Cut Off value useful to predict partial repair. *Results:* We have found statistical significance in predicting partial repair on MRI mesurements of Fatty Infiltration (FI grade ≥3; test di Fisher p<0.001), Patte Stage (grade= 3; test di Fisher p<0.001), Tear size measured in ML (>36 mm; Mann-Whitney p<0.001), Positive Tangent Sign (Chi-quadro p<0.001; sensitivity 95,3%, specificity 83,6%), Occupation Grade (OG <0,46; t-test p<0.001). Acromion-Humeral Distance (AHD <7 mm), Inferior Gleno-Humeral Distance (IGHD >5 mm). Tear size measured in AP (>21 mm; Mann-Whitney p<0.001) seems to be dependent on the contextual size of the lesion in ML. We haven't found statistical significance in predicting partial repair of Glenoid Version Angle. *Conclusions:* A systematic observation of seven independent MRI parameters (FI, PS, tear size ML, TS, OG, AHD, IGHD) can help the surgeon to predict the impossibility to obtain complete repair of RCT and to consider different surgical approach. (www.actabiomedica.it)

Key words: rotator cuff tear, magnetic resonance shoulder, partial repair, tangent sign, occupation grade

Introduction

When orthopaedists evaluate rotator cuff tears on MRI imaging, always have a concreat idea about the grade of reparability that artroscopic treatment would lead to, due to personal experience. It is recognised that a significant percentage of large and massive rotator cuff tears (RCT) undergo a partial repair and this correlates with a worse outcome in terms of pain, range of motion, increased incidence of retear (1, 2, 6, 31). We would like to clarify some definitions first: by the term "Partial repair" we consider a surgical repair that obtain <50% footprint coverage (1, 3, 4); referring to De Orio-Colfield Classification (8), tears >50 mm, mesured in

any direction, are traditionally classificated as "massive", tears between 30 and 50 mm are classificated as "large" (1, 2, 8, 9). In the last fifteen years lots of study have analyzed MRI parameters linked to large and massive tears. Some correlation are already widely know and shared: the role of rotator cuff atrophy, increased muscolar fatty infiltration, grade of muscolar retraction (Patte Stage). Other parameters (Tangent Sign, Occupation Grade, Glenoid version agle) were evaluated less frequently in litterature and substantially in population composed by patients with large and massive tears, lacking of a "control group" of patients with less extensive tears (5). The aim of this study is to evaluate if it was useful or possible to obtain parameters from pre-operative MRI that could provide an index of rotator cuff reparability: thus will assist ortopeadists in surgical planning.

Materials and method

We performed a retrospective study on a population of 131 patients subjected to arthroscopic cuff repair by a single expert surgeon, between January 2016 and September 2017. Population was composed by 53% males and 47% females; 78 patients undergoing arthroscopic treatment of isolated supraspinatus lesions (59,54%), 53 patients undergoing arthroscopic treatment of combined lesions of supra and infraspinatus (40,46%). We have excluded from the study patients who had an associated subscapularis lesion or shoulder instability or patients who have undergone previous shoulder surgery.

Pre-operative MRI images came from 4 different centres, including our hospital: two radiological centres had 0,4 Tesla MRI's, olthers had 1,5 Tesla MRI's.

Waiting times between the execution of the MRI and surgery were on average 3 months. Pre-operative MRI images were evaluated by a single orthopaedist, trained on MRI shoulder images ad blinded to surgical outcome. For each MRI we evaluated the following 9 parameters: Patte stage (PS), tear size measured in medial-lateral (ML) and anterior-posterior (AP) dimension, Fatty Infiltration (FI), Tangent Sign (TS), Occupation Grade (OG), Acromion-Humeral Distance (AHD), Inferior Gleno-humeral distance (IGHD), Glenoid Version Angle (GVA). All measurements were calculated using O3 Reporting Workstation (ORWS Insiel FVG Version 3.2.2) with an accuracy up to 0,01 mm. Than we divided population into two groups: patients that obtained a complete repair of RCT (n=110; 83,97%) and patients that obtained only a partial repair of RCT (n=21; 16,03%). For each MRI parameter we conducted statistical analyses (Student's t test, Mann-Whitney U test, Shapiro-Wilk test, Chi-square test, Fisher exact test, ROC curves and maximum Youden index) to find a Cut Off value to predict partial repair.

MRI parameters

Patte Stage (PS)

Patte stage was evaluated on coronal T1 (Figure 1). Patte Classification divides tendon retraction degree into 3 stages. Stage 1: sovraspinatus tendon retraction remain lateral to the humeral head cartilage; Stage 2: sovraspinatus tendon edge is located between the humeal head and the glenoid margin; Stage 3: sovraspinatus tendon edge is located to the glenoid or beyond the glenoid (16).

Medial-lateral tear size (ML)

Tear size was measured on the same Coronal T1 image in which we had evaluated Patte Stage. Measure was taken drawing a straight line from the most lateral part of humeral tendon footprint to the edge of

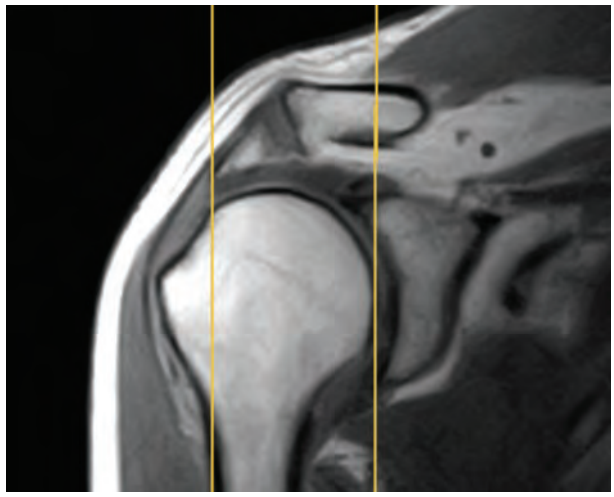


Figure 1. Patte Stage 3; Coronal Sequence T1

retracted sovraspinatus tendon (5, 9). If this sequence was not avaible, measures were taken on T2 sequences (Figure 2).

Antero-Posterior tear size (AP)

Tear size was measured on Sagittal T2 sequences, drawing a straight line form anterior edge of lesion to the intact cuff tendon, thus comprising the lesion of the supra and infraspinatus (5, 9). If this sequence was not avaible, measures were taken on T1 sequences (Figure 3).

Fatty Infiltration (FI)

The assessment of degree of fatty infiltration was obtained using MRI re-adaptation of the Goutallier Fatty index (7, 10). The most useful MRI image to classified Fatty infiltration is the first lateral T1 sagittal image where scapula is "Y-shaped": the scapular spine is seen in contact with scapular body, defining a Y bone image (11). Fatty infiltration was defined as Grade 0: no fatty infiltration; Grade 1: some fatty streacks; Grade 2: more muscle than fat; Grade 3: same proportion of muscle and fat; Grade 4: more fat than muscle (Figure 4).

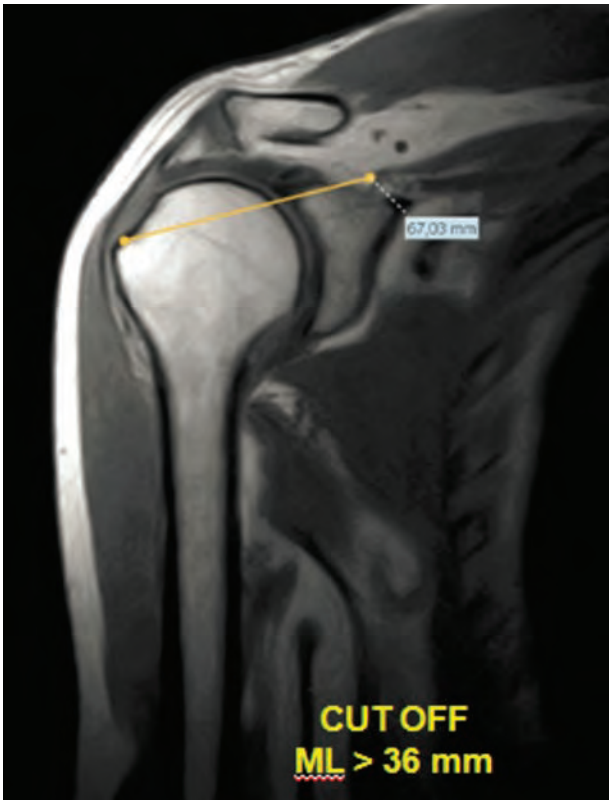


Figure 2. Tear ML dimension; Coronal Sequence T1. Cut off Value ML is 36 mm: it means that tear size >36 mm is associated with the inability to obtain a complete cuff repair

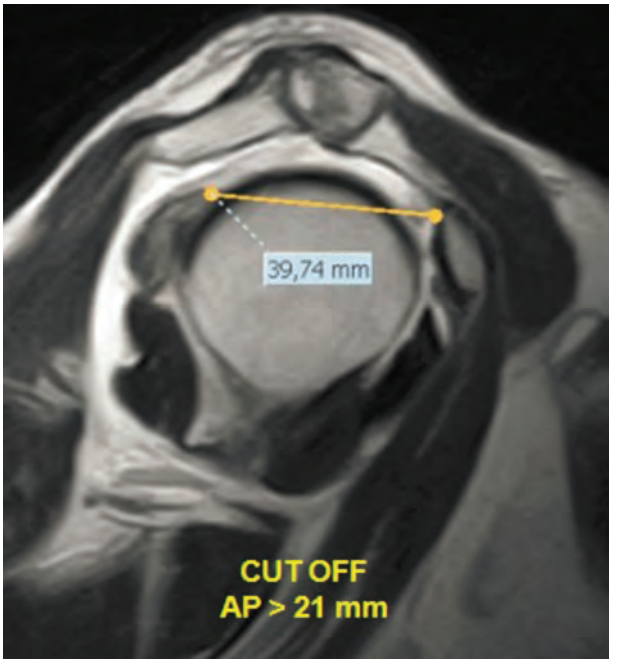


Figure 3. Tear AP dimension; Sagittal Sequence T2. Cut Off value AP is 21 mm

Tangent Sign (TS)

Tangent Sign was measured on the same Sagittal T1 image in which we had evaluated Fatty Infiltration. On the Y shaped section, a straight line is drawn to join the upper portion of the coracoid with the upper portion of the scapular spine: TS is considered positive if the supraspinatus muscle does not cross the tangent, lying under the tangent line (Figure 5).

Occupation Grade (OG)

Occupation grade was measured on the same Sagittal T1 image in which we had evaluated Fatty Infiltration and Tangent Sign: it's calculated as ratio between the cross sectional area of supraspinatus muscle and area of supraspinatus fossa under the Tangent Sign line (Figure 6) (5, 17).

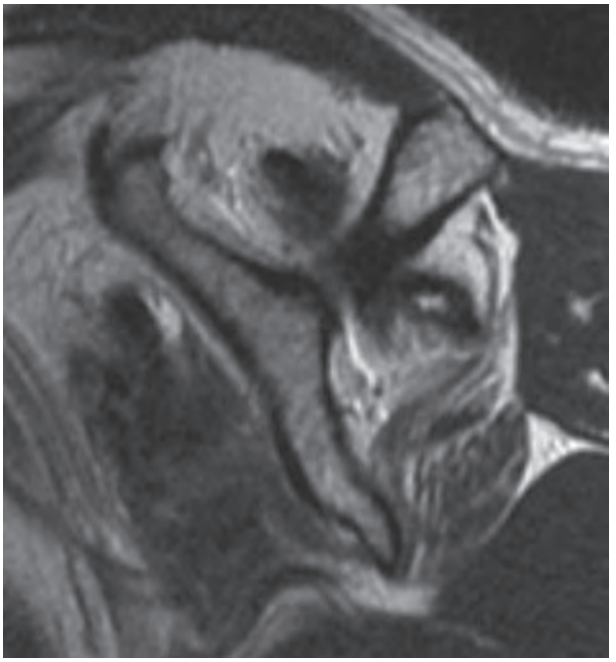


Figure 4. Fatty Infiltration Grade 4; Sagittal Sequence T1

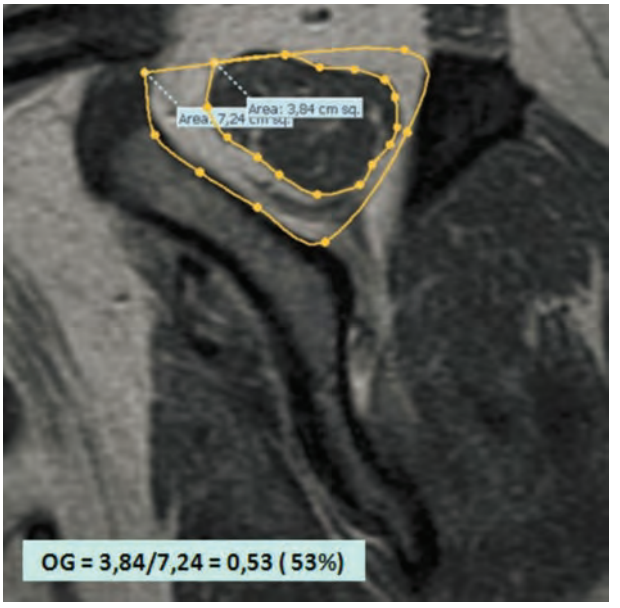


Figure 6. Occupation Grade (OG) is calculated as ratio between the cross sectional area of supraspinatus muscle and area of supraspinatus fossa under the Tangent Sign line

Acromion-Humeral Distance (AHD) and Inferior Gleno-Humeral Distance (IGHD)

AHD and IGHD were measured on the same Coronal T1 image in which we had evaluated Patte Stage and ML tear dimension (Figure 7). AHD was measured with arm in neutral position, drawing a straight line from the middle point of anterior acromion to superior humeral cortex (20). IGHD was measured with arm in neutral position, drawing a straight line from the inferior humeral cortex to the inferior glenoid apex.

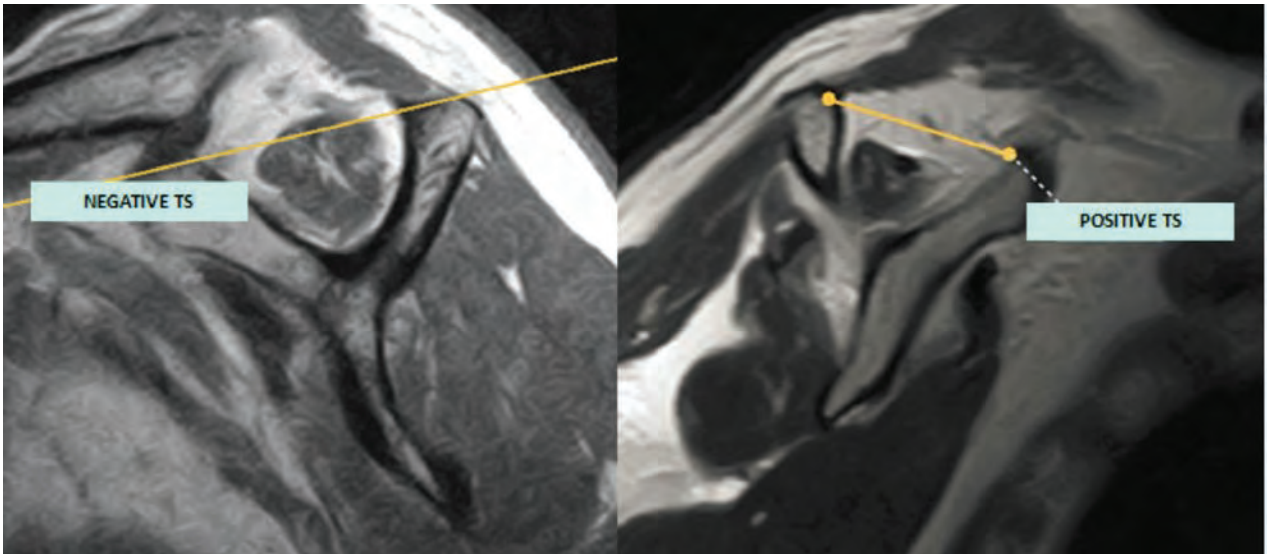


Figure 5. Example of Negative and Positive Tangent Sign (TS)

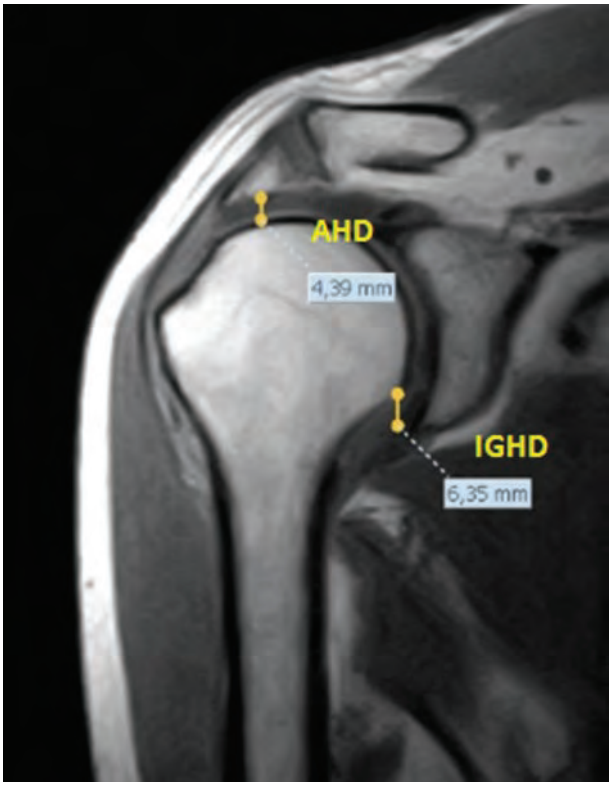


Figure 7. Acromion-Humeral Distance (AHD) and Inferior Gleno-Humeral Distance (IGHD); Coronal Sequence T1. Cut Off value for AHD is 7 mm; Cut Off value for IGHD is 5 mm

Glenoid version Angle (GVA)

Mesure for GVA were obtained on axial sequences, on the first cut immediately beneath sovraspinatus muscle where posterior border of glenoid neck is clearly visible (Figure 8): the sovraspinatus fossa axis was draw by joining the posterior glenoid neck to the point of conjunction of scapular spine to scapular body; than axis of glenoid osseus surface was draw (26). Angle α was the angle in the posterior medial quadrant of the intersection of these two lines. GVA was calculated by subtracting 90° from α angle (GVA=α -90°): glenoid anteversion was indicate as positive GVA values, while retroversion as negative GVA values (27).

Statistical Analysis

Descriptive statistics were used to report continuous variables (mean±standard deviation or median with range, depending on normal vs non-normal distribution of the data). The Shapiro-Wilk test was used to assess whether data were normally distributed. Categorical variables were reported as frequencies and percentages. For categorical variables, Chi-square test or Fisher exact test were conducted in order to detect

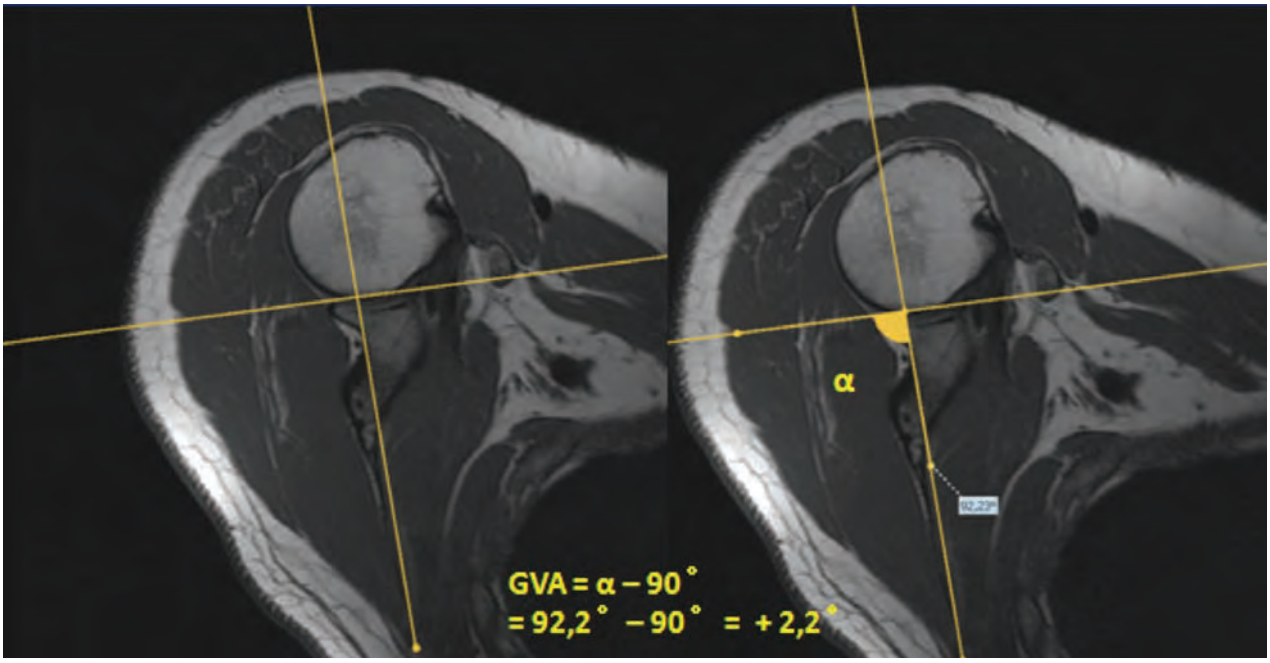


Figure 8. Glenoid Version Angle. Axial Sequence T1

significant differences between the two groups (complete RCT repair vs partial RCT repair), as appropriate. The Student's t test or the Mann-Whitney U test was used to compare continuous variables between the two groups, as appropriate. ROC curves were performed to assess effectiveness of continuous variables in predicting reparation pattern, and maximum Youden index was calculated to identify an empirical optimal Cut-off (maximization of both sensitivity and specificity).

Statistical significance for all tests was set at a p-value of <0.05. All statistical analysis were performed by Stata/IC 13.0 (StataCorp LP, College Station, USA).

Results

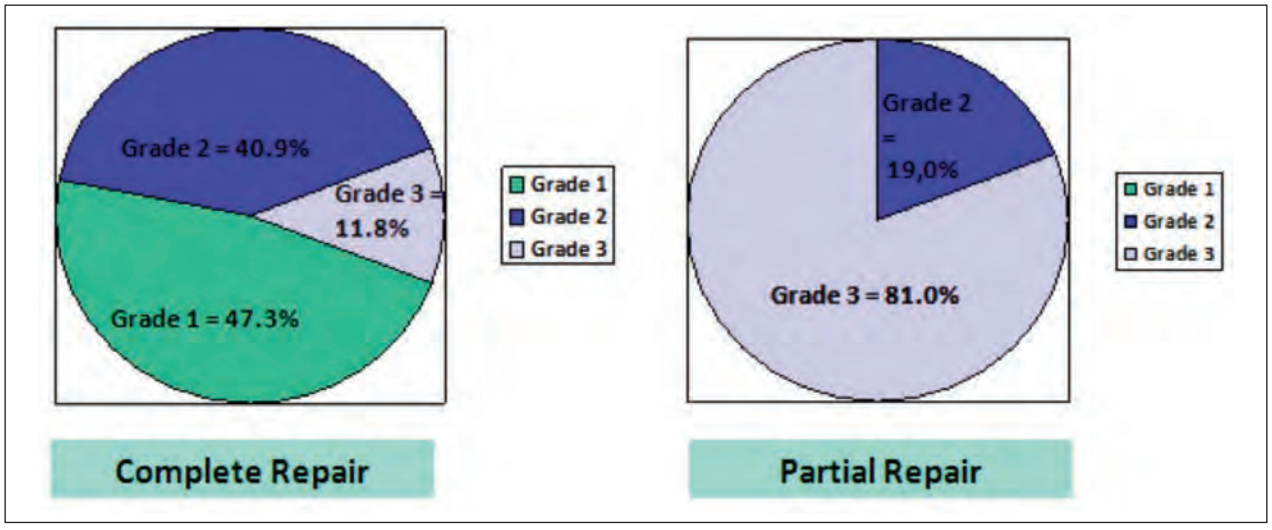
Comparing two groups (Partial Rotator Cuff repair / Complete Rotator Cuff repair) we point out that there is a clear dominance of the male sex in the group that obtained a partial repair (81%; test Chi-quadro p=0.005). We found no evidence of significance in the two groups regarding age differences nor in merit of the presence of a recent trauma (in the previous 6 months) reported in anamnesis.

Stage 3 in Patte classification was found in 81% of pre-operative MRIs in patients who subsequently achieved partial cuff repair, compared to the predominance of Stage 1 (47,3%) and Stage 2 (40,9%) in patients who achieved complete cuff repair (Graphic 1). High statistical significance of this data was confirmed by Fisher test (p<0.001).

Tear dimension in Medial-Lateral (ML) was measured on the same Coronal image in which we had evaluated Patte Stage: the statistical median for Partial rotator cuff repairs was 52.8 mm with range [31.0 mm - 67.0 mm], the statistical median for Complete rotator cuff repairs was 19.7 mm with range [8.5 mm - 46.8 mm], with remarkable statistical difference in two groups (Ranksum-test di Mann-Whitney p<0.001). Cut Off value for Tear dimension in Medial-Lateral (ML) was 36 mm (Youden Index 0,818; Sensitivity at cutpoint: 1.00; Specificity at cutpoint: 0.82) (Figure 2).

Tear dimension in Anterior-Posterior the statistical median for Partial Rotator Cuff repairs was 28.0 mm with range [14.6 mm - 48.4 mm], the statistical median for Complete rotator cuff repairs was 12.8 mm with range [8.9 mm - 32.4 mm], with remarkable statistical difference in two groups (Ranksum-test di Mann-Whitney p<0.001). Cut Off value for Tear dimension in Anterior-Posterior (AP) was 21 mm (Youden index 0.823; Sensitivity at cutpoint: 0.90; Specificity at cutpoint: 0.92) (Figure 3).

The degree of fatty infiltration was assessed on the readaptation for MRI of Goutallier Fatty Index, it re-



Graphic 1. Patte Stage measured on pre-operative shoulder MRI in patients who obtained complete Rotator Cuff repair and patients who obtained partial Rotator Cuff repair

Table 1. Muscolar Fatty Infiltration percentage found in pre-operative shoulder MRI

GRADO	FATTY INFILTRATION	COMPLETE REPAIR	PARTIAL REPAIR
0	No fatty deposits	1,1 %	0%
1	Some fatty streacks	33,5 %	14,1%
2	Muscle > Fat	60,0 %	14,3%
3	Muscle = Fat	3,6 %	52,5%
4	Muscle < Fat	1,8%	19,1%

DICOTOMIZED VARIABLE

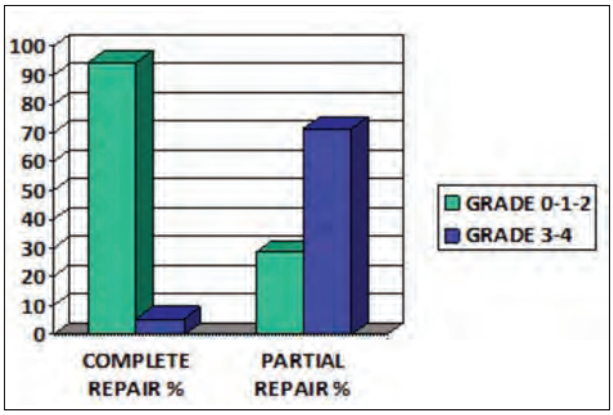
confirms in our study how important a grade 3-4 is in influencing a partial repair (Table 1).

This data is further highlighted by the merging of grades 0-1-2 and 3-4 (Graphic 2): it is possible to notice that 94% of complete repairs the degree of fatty infiltration assessed at the pre-operative MRI was between 0 and 2, while partial repairs showed in 72% of cases 3-4 degrees. High statistical significance of this data was confirmed by Fisher test (p<0.001).

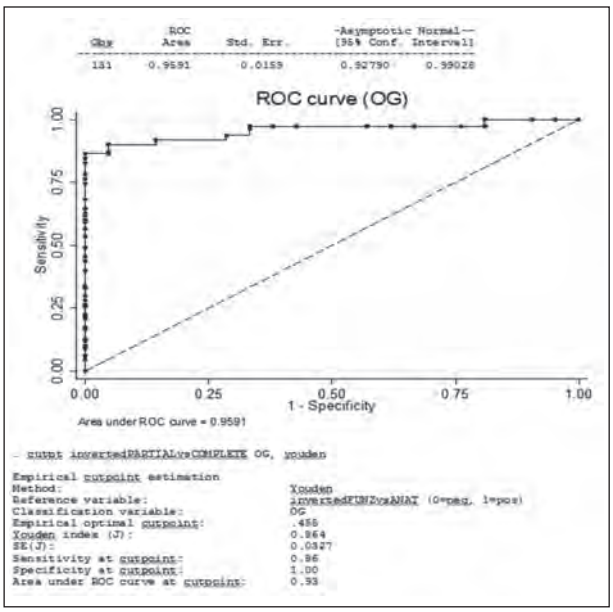
Positive Tangent Sign showed a sensitivity 95,3%, specificity 83,6% (Chi-quadro p<0.001) in predict a Partial cuff repair.

In the evalutation of Occupation Grade, the statistical mean±DS for Partial rotator cuff repairs was 33.0%±7.2%, the statistical median for Complete rotator cuff repairs was 63,2%±16,7%, with remarkable statistical difference in two groups (t-test p<0.001). Cut off value for Occupation Grade was 46% (0,46) (Youden index 0.864; Sensitivity at cutpoint: 0.86; Specificity at cutpoint: 1.00) (Graphic 3).

Acromion-Humeral Distance (AHD) showed a statistical mean±DS for Partial rotator cuff repairs of 5.4 mm ± 1.7 mm and a statistical mean±DS for



Graphic 2. In 94% of Complete RCT Repairs fatty infiltration Grade, assessed at the pre-operative MRI, was between 0 and 2, while Partial RCT Repairs showed in 72% of cases Grade 3-4



Graphic 3. ROC Curve for Occupation Grade (OG); Cut Off value is 0,46 (46%), Sensitivity at Cut Point 0,86; specificity at Cut Point 1,00

Complete rotator cuff repairs of 8.0 mm ± 1.4. These differences were statistically significatives at t-test ($p<0.001$). The Cut off value of AHD <7 mm predict a partial reparability of Rotator Cuff lesion (Youden index: 0.630; Sensitivity at cutpoint: 0.77; Specificity at cutpoint: 0.86)

Inferior Gleno-Humeral Distance (IGHD) showed a statistical median for Partial rotator cuff repairs of 6.9 mm with range [4.2 mm -14.8 mm] and a statistical median for Complete rotator cuff repairs of 4.5 mm with a range of [0.0 mm- 9.8 mm]. These differences were statistically significatives at Ranksum-test Mann-Whitney ($p<0.001$), The Cut off value of IGHD >5 mm predict a partial reparability of Rotator Cuff lesion (Youden index: 0.464; Sensitivity at cutpoint: 1.00; Specificity at cutpoint: 0.46)

Glenoid Version Angle (GVA) showed a statistical mean±DS for Partial rotator cuff repairs of -1.0°±4.7° and a statistical mean±DS for Complete rotator cuff repairs of -1.5°±3.7°. These differences weren't statistically significatives at t-test ($p=0.594$).

Discussion

Our study confirms the role of tear size and Patte stage in influencing a rotator cuff's partial repair. This evidence is already largely shared. We have associated the medial-lateral lesion measurement with the evaluation of Patte Stage. Tracing a medial-lateral straight line we clearly have done an approximation and understimation of the real tear size but the aim of this study is to furnish a pratical an rapid method of MRI's evaluation that can be really applied during clinical practice, so, agreeing with previous studies (5, 9), we have choosen this method. More interesting than underlining the absolute mean and median values in the two groups, it seemed practical to indicate a cut-off value to which to refer. The cut of value for medial-lateral tear size in our population is 36 mm: it means that tear size >36 mm is associated with the inability to obtain a complete cuff repair. We found a Cut Off value for anterior-posterior tear size in our population: 21 mm, but we think that this data is influenced by the fact that in our population the larger tears measured in ML were also larger in AP, so the AP size taken as single values is inconsistence in clinical practice (for example a Crescent lesion should be completely reperied also if it is larger than 21 mm in AP because there is little ML lesion size). As Holtby et al. showed (5), AP lesion size should be taken in consideration only combined to ML size, to give an area.

Our study also confirms the role of fatty infiltration (FI) and muscolar atrophy in influencing a rotator cuff's partial repair. Yoo et all. (2) showed how advanced sovraspinatus and infraspinatus fatty involution is associated with inability to obtain a complete repair. Other authors have found that this degeneration is reversible after rotator cuff repair and surgery could prevent the progression of fatty involution (12-14, 19).

Tangent Sign (TS) is a useful, easily performer and reproducible tool to evaluate supraspinatus atrophy. TS showed in our population sensitivity of 95,3%, specificity of 83,6% in predicting a partial repair (18). Considering a Positive TS, due to an evidence of different filling of supraspinosa fossa, an assessment of the Occupation Grade has been proposed by Thomazeu et al. (17). In our population we have found an Occupation Grade Cut off of 0,46 (46%): it means that OG values below 0,46 indicate an impossibility to obtain a complete Rotator Cuff repair.

Moreover, Jeong et al (24) evaluated 112 MRIs executed at 9 months post-operatively in patient who underwent arthroscopic rotator cuff repair for a large sized tear: they demonstrated that Occupation Grade of supraspinatus <0,43 (43%) and grade ≥2 fatty infiltration of the infraspinatus were the strongest predictors of retear, with sensitivity of 98.0%, and specificity of 83.6% (accuracy=90.2%).

Recently Sheean et al. (23) had demonstrate that a positive Tangent Sign and/or high-grade fatty infiltration (Grade ≥3) of the supraspinatus were risk factors for incomplete RCT repair, however, these were not completely predictive of reparability because the majority of massive RC tears with these imaging characteristics were still fully reparable.

Otherwise, in other studies (14, 15) immediate post-operative MRIs shows a significant improvement of fatty degeneration grade (one degree lower) and muscle atrophy (evaluated with Tangent Sign and Occupation Grade): they underline the role of tendon retraction as cause of false positive muscle atro-

phy ("pseudo-artrophy") on pre-operative MRI, found that the conventional Y shape view is distant from the osseus origin of sovraspinatus tendon, at which non attached muscle and tendon can freely retract; in conclusion they support that the immediate post operative MRI should be the baseline study to visualize the real muscolar quality on Y shaped view.

However, on the basis of the evidence found, we confirm that the pre-operative assessment of the degree of atrophy (using TS and OG) and fatty infiltration provides, even taking into account false positives, an excellent pre-operative planning meter. On the other hand, we find less useful to request a MRI in the immediate post-operative period only to obtain a basic value of muscular atrophy.

The cut off value we had found for AHD (<7 mm) are in line with what was found by Flatow at al. (20), Hamada et al (21), Snyder et Al (22). In 1994, Flatow et al. (20) assessed the subacromial space of a normal X-ray, quantifying it as being an average of 10-15 mm, mean acromio-humeral interval was 11.1 mm at 0° of elevation in normal shoulders and 6 mm or less in 50% of patients with rotator cuff tears. In Hamada Classification (21) Grade 1 was defined as an ADH ≥6 mm, Grade 2 as ADH ≤5 mm, Grade 3 as acetabulization (concave deformity of the acromion undersurface) plus an AHI ≤5 mm, Grade 4 as narrowing of the glenohumeral joint plus conditions required for grade 3, and Grade 5 as humeral head collapse. Recently Shim et al. Demonstrated that ADH is an independent risk factors for irreparabile RCT, whereas Critical shoulder Angle and Acromial Index were not: mean AHD of Shim at al. patients was 8.007 mm, range [0.8 mm -18.5 mm] (25).

We found few studies attesting the utility of IGHD (5, 9). In our study we showed that the cut off value of IGHD>5 mm is useful to suggest the impossibility to obtain a complete Rotator Cuff repair and IGHD measurement is easy and rapid to be performed.

The last parameter we have measured was Glenoid Version Angle. Our population showed a small degree of glenoid retroversion but these fact didn't correlate to final Cuff Repair. Tetrault et al. (26) reported that retroversion (mean-5°±4°) was associated with high probability of supraspinatus tendon injury but these study lack of a control group. Thus we agree with previous articles that confirmed that glenoid axis has a great variability and is not related with Rotator Cuff Tears (27, 28). If there are significant anatomical glenoid abnormalities, such as Bankart lesions, it is useful to complete the pre-operative study with evaluation of glenoid bone loss by Multiplanar Reconstruction Curved Computed Tomographic imaging (cMPR – TC) (33).

One limitation of this study was related to different numerosity of two groups esamine (Partial repair n°=21 patients; Complete repair n°=110 patients).

It is also important to consider that choosing these Cut Off values, we had done a compromise between a useful maximization of sensitivity and specificity.

Another limitation was that pre-operative MRI's came from 4 different main Radiological centres: we had examinated MRI with different image quality (0,4 Tesla or 1,5 Tesla) and in a few MRI's arm position was not compliant with the standard position (29), thus influencing some measurements, expecially IGDH if the arm was internally rotated. Moreover, we have not always had the best MRI sequence available to examine specific parameter (29). Moreover, only one trained orthopaedist made each measurements, we didn't verify inter-observer variability: however previous studies showed good inter-observer reliability (4, 5, 9, 14, 30).

Finally, as is know, the presence of subcutaneous implants, such as permanent defibrillators, is an absolute contraindication to the use of MRI. Moreover, MRI is unadvisable in subjects with metallic hardware near the area of study, as artifacts generated by such materials distort image quality: for those patients, Multidetector Computed Tomography Arthrography (Arthro-MDCT) of the shoulder is a safe technique that provides accurate diagnosis in identifying chondral, fibrocartilaginous and intra-articular ligamentous lesions (32).

Conclusion

We found statistical significance in predict partial repair analyzing pre-operative MRI mesurements of seven independents MRI index. For each parameter we have found a cut of value, useful in clinical practice, as summarize in (Table 2).

Table 2. Useful MRI index to evaluate Rotator Cuff Reparability

INDEX	CUT OFF PARTIAL REPAIR
Tear dimension **ML**	**ML > 36,5 mm**
Acromion-Humeral Distance **AHD**	**AHD < 7 mm**
Inferior Gleno-Humeral Distance **IGHD**	**IGHD > 5,7 mm**
Fatty Infiltration **FI**	**FI ≥ GRADO 3**
Patte Stage **PS**	**PS = GRADO 3**
Tangent Sign **TS**	**TS POSITIVE (sens. 95%, spec. 90%)**
Occupation Grade **OG**	**OG <0,43**

Our cut of values predicting parzial repair are: Fatty Infiltration (FI grade ≥3), Patte stage (PS grade= 3), tear size measured in ML (ML>36 mm), Positive Tangent Sign (sensitivity 95,3%, specificity 83,6), Occupation Grade (OG<0,46), Acromion-Humeral Distance (AHD<7 mm), Inferior Gleno-Humeral Distance (IGHD>5 mm).

A systematic observation of seven MRI index can help the ortopeadist, especially when less experienced, to predict the impossibility to obtain complete repair of RCT and to consider and plan different surgical approach.

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Original article

Cementless metaphyseal reverse shoulder arthroplasty: our preliminary experience

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Summary. Reverse shoulder arthroplasty (rTSA) is a largely used procedure with a wide variety of indications. The incidence of this surgery is increased in recent years and the literature expects similar trend for the future. Metaphyseal stem rTSA seems to be a promising solution considering major objectives the preservation of humeral bone stock and ease of revision. In our study we analyzed 19 patients treated with cementless metaphyseal stem rTSA for osteoarthritis (group A) and acute fractures (group B). In group A (7 patients) the average Constant score improved from 21,57 (16-29) to 56,85 (38-72), the average SST improved from 2,29 (1-4) to 9,43 (8-12) and the mean VAS score improved from 14,29 to 4,86. In group B (12 patients) the mean Constant-Murlay score at last follow up was 42,17; the average SST was 7 and average pain score was 8,92. Overall active range-of-motion (ROM) improved significantly. Surgical considerations, clinical (analyzing Constant score and Simple Shoulder Test) and radiological short-term outcomes are encouraging, with low rate of complications. Long term follow-up studies are necessary to confirm our findings and the potential benefits related to these implants. (www.actabiomedica.it)

Key words: shoulder arthroplasty, reverse shoulder arthroplasty (rTSA), range-of-motion (ROM)

Introduction

The incidence of reverse shoulder arthroplasty (rTSA) is lower than hip and knee prostheses (1-3) but the number of implants is increased in last years and this trend should continue due to increasing of high demanding patients, better health care capacity and expanding indications (4-6).

In USA 42% of all shoulder arthroplasties were rTSAs in 2011 (7) with a large use in patients <60 years (8, 9).

Several designs, materials and implant characteristics are available and the indications are in particular glenohumeral osteoarthritis with rotator cuff deficiency and severe humeral head-neck fractures in elderly patients (10-15).

On the basis of these considerations and the necessity to treat often young patients that probably will need also revision surgery, short stem and metaphyseal implant recently emerged (16-22). Short-term studies reported functional and radiological results similar to the gold standard shoulder stemmed implants (16, 23).

The aim of the study is to share our experience and preliminary results with a cementless rTSA with metaphyseal stem in both glenohumeral osteoarthritis and acute fractures.

Materials and methods

Between May 2016 and June 2018 19 patients underwent rTSA by the senior author (G.S.) utilizing a cementless prosthesis with short metaphyseal stem (Verso®; Innovative Design Orthopaedics, London, UK) and also the stemmed version proposed for the treatment of acute fracture.

Seven patients suffer for glenohumeral arthropathy with deficient rotator cuff (Group A - Fig. 1) and twelve patients had acute displaced fractures of the proximal humerus (Four parts or more according to Neer classification) with rotator cuff dysfunction (Group B - Fig. 3).

In group A there were 2 male and 5 females, the mean age at surgery was 77,33 years (range 65-88 years) and the average follow up was 6,43 months (range 5-9 months)

In group B there were 4 males and 8 females, the mean age at surgery was 79 years (range 68-84 years) and the average follow up was 5 months (range 3-9 months).

Surgical Technique

The surgery was performed with the patient in "beach chair" position under general anesthesia with interscalene block (blended technique).

In group A patients all the procedures were performed through the anterosuperior approach to the shoulder (Neviaser-MacKenzie approach) while in group B patients though the deltopectoral approach.

In group A patients any remnants of subscapularis or infraspinatus were detached and tagged with stay sutures.

Minimal proximal humeral bone resection was performed and the cancellous bone was used for bone graft impaction technique as purposed by Levy et al (19) and other authors (24).

In group B after individuation and isolation with stay suture of greater and lesser tuberosity parts, the humeral head was remove and used for bone graft impaction technique.

The humeral stemless component was implanted in group A patients while the humeral stemmed component was used in group B patients.

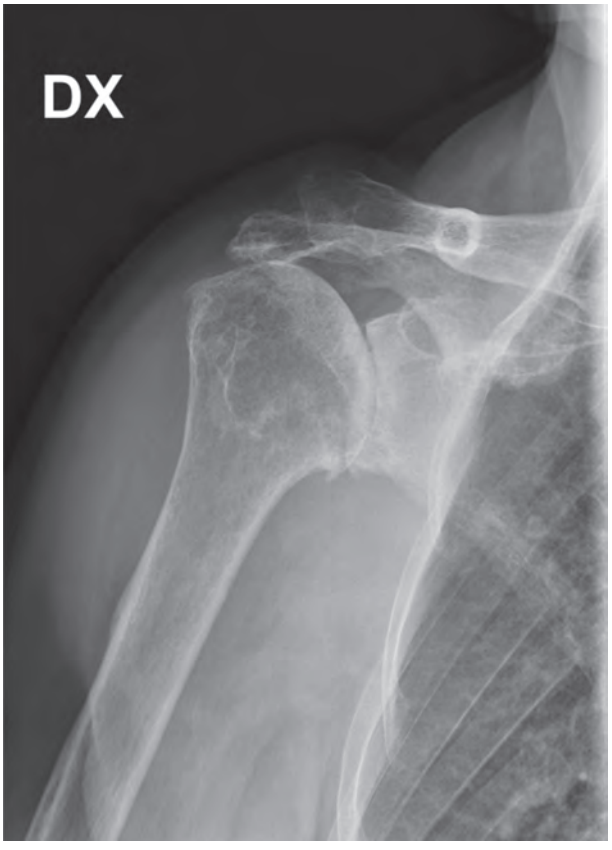

Figure 1. Preoperative x-rays

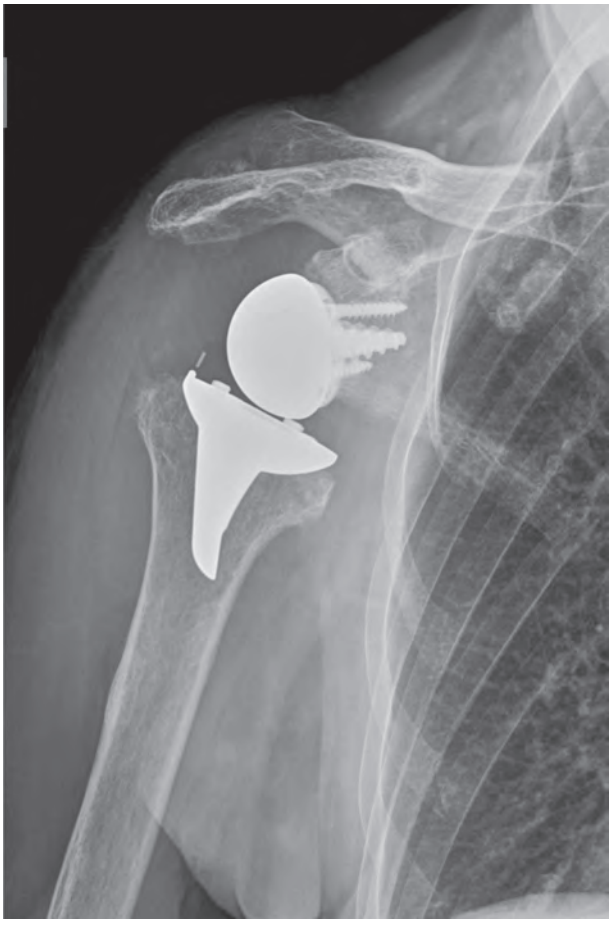

Figure 2. Tthree months follow up x-rays

Good initial press-fit fixation was achieved in all patients.

Standard glenoid component was implanted in all patients.

Tuberosities re-attachment was performed using non-absorbable suture (Orthocord® DePuy Sinthes Raynham, Massachussetts, USA) in all cases when possible.

Postoperative rehabilitation included sling immobilization for 2 weeks followed by passive range-of-motion exercises after 2-3 weeks, active range-of-motion exercises after 4-6 weeks and incorporation of strengthening from week 12-20.

Assessment

Patient evaluation was performed by independent observers pre operatively (only in group A) and at 3,6 and 9 months.

Functional outcome was evaluated with Constant score (pain, activities of daily living, active range of motion and shoulder strength). Range of motion was measured with a goniometer. Active internal rotation was measured as the highest spine level that the patient's thumb could reach. Patients satisfaction was assessed using the Simple Shoulder Test (SST), a functional questionnaire assessing return to work, sport and leisure activities.

Pain relief was assessed on a 0-15 Visual Analogue Scale (VAS).

Radiograph evaluation was performed analyzing AP and axillary view of the shoulder for any evidence of complication including displacement, migration, subsidence of the implant and appearance of radiolucent lines, osteolysis or sign of stress shielding (Fig. 2, 4).

Statistical methods

Statistical analysis was performed using Microsoft Excel (2017 version).

In group A patients improvement in Constant score or SST score were calculated for each case by

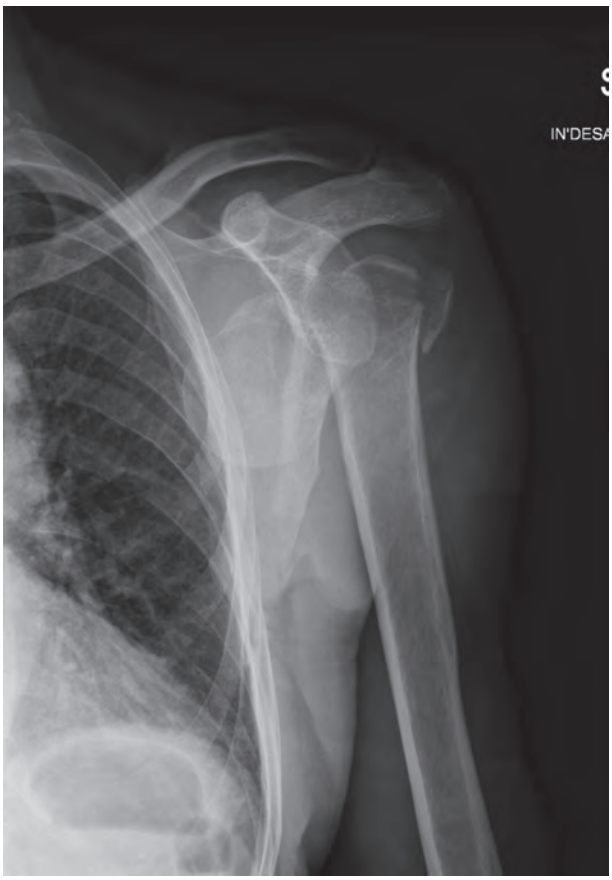

Figure 3. Preoperative x-rays

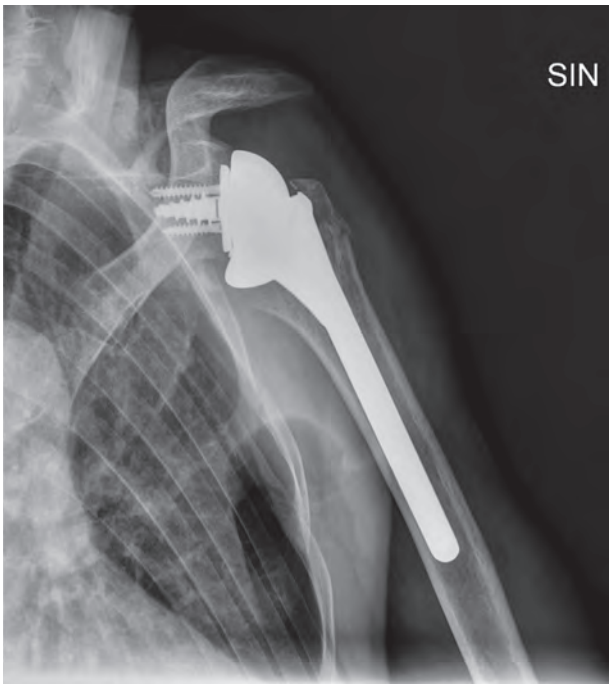

Figure 4. Six months follow up x-rays

comparing the latest observed postoperative value against the corresponding preoperative value and the significance of the difference was tested using the paired t test.

Results

In group A patients the average Constant score improved from 21,57 (16-29) to 56,86 (38-72), the average SST improved from 2,29 (1-4) to 9,43 (8-12) and the mean VAS score improved from 14,29 to 4,86.

All these gains were statistically significant ($P<0.001$)

Overall active range-of-motion (ROM) improved significantly (Tab. 1).

In group B patients the mean Constant-Murlay score at last follow up was 42,17, the average SST was 7 and average VAS score was 8,92.

Average active range of motion at last follow up is described in table 1.

There were no cases of intraoperative fractures or dislocations in follow-up period.

No findings of subsidence, radiolucent lines around the components and notching at the radiological follow up. No signs of mobilization or position changing over the time of the humeral stem were recognized.

One patient in B group presented axillary nerve palsy after surgery, but it recovery spontaneously within six months.

At the time of the study no patient had undergo to revision surgery.

Discussion

The decision to perform a study analysing both stemmed and unstemmed version of this prosthesis come from the concept that with Verso the surgeon doesn't have to obtain the cortical press fit with the stem as usually performed with the majority of the available implants (19, 25).

The stemmed version used for the treatment of acute fracture has the same proximal shape of the stemless implant for achieve the primary stability while the distal part works like a "rudder" in particular in complex fracture patterns. The press fit is with metaphyseal cancellous bone in both groups.

We decided to perform the anterosuperior approach in group A patients while the deltopectoral approach in group B patients. The reason is that we usually use the deltopectoral approach for all the other implants and indications and we believe is easier to enlarge distally in case of peri-implant or intraoperative fractures. Nevertheless we observe that the exposition and preparation of the anatomical structures, in particular the glenoid, is better with the anterosuperior approach, that allows to perform also the open acromion-clavicular decompression and the best suture of the posterior cuff to the humeral bone.

In all cases the glenoid preparation is performed carefully, in particular the round movements of the handy reamer should be as gentle as possible because the pressure exerted on the glenoid bone is very high.

In both groups the humeral preparation is conducted saving much cancellous bone possible. The three tapered thin fins give a theoretical immediate methaphyseal press fit fixation as reported in literature (19, 25). The sensation of stability is not always so secure after the insertion of the last humeral punch, in particular in case of fractures when surgical humeral neck is involved.

In this stage a key role is played by the "bone graft impaction technique" (19, 24) that consists in morselize the cancellous bone of the humeral head and put the small pieces inside the metaphysis between first and last humeral punch insertion and before the humeral shell positioning. Thus in combination with the titanium and hydroxyapatite coating of the definitive humeral component give always a sensation of stability to the surgeon in all cases of our series, and allowed us to avoid the use of cement that could complicate any further revision surgery.

In our opinion the highest difficulty is to move from the concept of achieve cortical press fit to methaphyseal cancellous bone press fit and trust in this philosophy.

Analyzing clinical results all patients had good pain relief and statistical significative improvement of Constant-Murlay and SST scores according to the recent literature (26-28). Considering the ROM the

Table 1.

ARTROSI	ETA'	FOLLOW UP	CONSTANT PRE	CONSTANT POST	PAIN PRE	PAIN POST	ER PRE	ER POST	IR PRE	IR POST	ABD PRE	ABD POST	FLEX PRE	FLEX POST	SST PRE	SST POST
1	65	5	17	38	15	10	0	15	10	50	45	110	30	120	1	8
2	69	6	22	64	12	4	10	30	30	60	60	150	45	150	3	10
3	88	6	16	44	15	6	5	60	10	70	45	150	45	150	2	8
4	71	9	29	72	14	0	5	75	25	90	70	180	60	180	4	12
5	67	7	20	55	15	5	0	60	10	60	45	150	30	150	1	8
6	79	6	25	67	14	2	5	60	20	70	60	180	45	180	3	10
7	73	6	22	58	15	7	0	60	20	60	45	130	30	150	2	10
MEDIA	73,1428571	6,42857143	21,57142857	56,85714286	14,2857143	4,85714286	3,57142857	51,4285714	17,8571429	65,7142857	52,8571429	150	40,7142857	154,285714	2,28571429	9,42857143
SD	7,96719464	1,27241802	4,503966506	12,30756639	1,11269728	3,28778403	3,77964473	20,9591439	8,09173594	12,7241802	10,3509834	25,1661148	11,3389342	20,7019668	1,11269728	1,51185789
p value			<0.0001		<0.0001		0.0001		<0.0001		<0.0001		<0.0001		<0.0001	

FRATTURE	ETA'	FOLLOW UP	CONSTANT POST	PAIN POST	ER POST	IR POST	ABD POST	FLEX POST	SST POST
1	82	3	58	7	10	50	130	150	8
2	78	3	38	8	20	45	60	120	7
3	73	4	44	10	10	30	60	120	7
4	84	6	32	10	10	45	90	90	6
5	80	6	48	8	10	45	60	150	6
6	72	3	39	7	30	30	90	120	7
7	76	5	55	5	60	60	120	150	8
8	75	4	37	10	10	30	90	90	6
9	80	6	49	8	30	45	60	120	8
10	77	8	33	12	10	20	45	60	5
11	68	9	44	10	20	30	60	90	10
12	83	3	29	12	10	30	45	90	6
MEDIA	77,3333333	5	42,16666667	8,916666667	19,1666667	38,3333333	75,8333333	112,5	7
SD	4,81160214	2,04494943	9,13368723	2,108783938	15,0504203	11,5470054	28,028665	28,959219	1,34839972

outcomes are encouraging, in particular regarding internal and external rotation. Several studies in literature analysing Grammont-type reverse arthroplasties reported poor values of rotation, our results could be positive influenced by the very low medial profile of polyethylene liner combined with the glenoid sphere offset and 30° of humeral shell retroversion as suggested by the technique (19).

In our opinion also the suture of the tuberosities as much as possible in the original anatomic position, is mandatory for obtaining the best ROM after rTSA surgery for both fracture and osteoarthritis patterns (29).

Radiological outcomes are excellent, without any complication (30), probably related to the short-term follow up (9 months maximum). Not in all cases, in particular in group A (shorter stem), the humeral stem was perfectly aligned with the diaphysis, in 2 cases there were small degrees of varus angulation but without any clinical implication.

In one series conducted with the same implant (Verso prosthesis) glenoid notching was observed in 21,4% of patients (19) lower than those reported in other studies on rTSA in literature (31-36). At the follow up time we didn't observe any case of glenoid notching probably related to the little cohort of patients and follow up duration.

Regarding the case of transitory axillary nerve palsy we hypothesized a strong relationship with high energy trauma. Neurological signs could be underestimated at the admission and the findings at the follow up not related to the surgical procedure. At six months follow up we observe spontaneous recovery of the nerve palsy, with good values of clinical scores and satisfaction.

Conclusions

Analysing the increase number of implants and the widening of the indications, in particular in younger patients, a cementless short stem reverse arthroplasty could be a precious solution in line with the principles of "tissue sparing surgery". Our preliminary experience has reported positive sensations and encouraging results. More randomized controlled studies about short stem rTSA are necessary and currently under clinical investigation. In our opinion advantages as easier revision with stemmed implant and periprosthetic fracture involving the metaphysis rather than diaphysis are useful and considerable.

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Original article

SLA-VER: study protocol description and preliminar results of the first italian RCT on conservative treatment of distal radial fractures

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Summary. *Introduction:* There is no consensus on which is the best way to maintain initial reduction of a distal radius fractures (DRFs). The aim of this study is to test the hypothesis that below elbow cast (BEC) is equivalent to above elbow cast (AEC) in maintaining initial reduction of DRFs. This paper will report on midterm results. *Methods:* SLA-VER is a prospective, monocentric, randomized, parallel-group, open label, blinded endpoint evaluation non-inferiority trial (PROBE design) comparing the efficacy of AECs and BECs in DRFs conservative treatment in terms of loss of radial height (RH), radial inclination (RI) and volar tilt (VT) during cast immobilization (average 35 days) of 353 consecutive DRFs. Non-inferiority thresholds are 2 mm for radial height, 3° for radial inclination and 3° for volar tilt. Study population will be 353 patients, randomized into 2 groups (AEC vs BEC). One-hundred patients have completed the study so far. *Results:* Patients in BEC group lost 1,75 mm of RH, 2,9° of RI and 4,5° of VT over the course of cast immobilization. Patients in AEC group lost 1,71 mm of RH, 2,2° of RI and 4,8° of VT. Raw differences between average loss of RH, RI, VT during treatment between study groups were respectively 0,04 mm, 0,7° and 0,3°. Logistic and ANCOVA models have been used to correct for confouding variables. *Conclusions:* Difference of loss of RH, RI and VT between the two groups are all below the non inferiority thresholds. Cast type does not seem to affect maintenance of reduction in conservatively managed DRFs. (www.actabiomedica.it)

Key words: distal radius fracture, cast, above-elbow cast, below-elbow cast, short arm cast, long arm cast

Introduction

Distal radius fractures (DRFs) represent a common clinical challenge in the everyday practice of an orthopaedic trauma department. The rising number of people affected by DRFs is most likely due to an aging population and the necessity of understanding the best possible treatment for these lesions is mandatory (1, 2). The absence of a consensus strategy has negative implications for the management of these common lesions, particularly in terms of quality of care and highest patient comfort. Optimal standard care for DRFs that are deemed to be treated conservatively has long been a matter of controversy. Currently, there is no general agreement on how to immobilize a DRF. Various methods have been described, but any approach has been proved more effective than the others (3-6). The latest clinical practice guidelines of the American Academy of Orthopaedic Surgeons, released in 2009, labeled the evidence available for or against elbow immobilization in patients treated with cast as "inconclusive", leaving the choice between them to the clinician's judgment (7). We designed a RCT to compare the two treatments. The Short vs- Long Arm cast, the

VERona trial (code name SLA-VER), expected to last 30 months and recruiting 353 patients randomly assigned to below-elbow cast (BEC) and above-elbow cast (AEC) will hopefully give guidance on the role of cast type in DRFs conservative treatment. This RCT, started at our institution on March 15th 2017, has until now recruited 162 patients. Recruitment is expected to be completed by 2019 and final results published by 2020. This paper will report on the midterm results of the study.

Methods

SLA-VER is a prospective, monocentric, randomized, parallel-group, open label, blinded endpoint evaluation non-inferiority trial (PROBE design) comparing the efficacy of AECs and BECs in DRFs conservative treatment. Its main goal is to test the non-inferiority of BECs as opposed to AECs to maintain reduction of manipulated DRFs. A secondary goal is to compare patient tolerability and quality of life of the two treatments. This study has been approved by the institutional review board of Verona and Rovigo (CE1165CESC) and registered on ClinicalTrials.org (NCT03468023). The study was conducted in accordance with the Declaration of Helsinki. All patients enrolled so far gave written informed consent. The study focused on the variation of radial height (RH), radial inclination (RI) and volar tilt (VT) over the course of treatment. To aimily reach 89% power to show any difference between the treatments with a two-sided type 1 error rate of 5%, we calculated that 150 patients would be required for each group using 2 mm difference in RH, 3° difference in RI and VT as non-inferiority thresholds. These estimates of minimal clinically relevant differences were based on previous reports of interobserver variability of up to 3° in radiographic parameter measurement and considerable deterioration of clinical outcome when loss of RH was more than 5 mm (8-10). We then added 53 additional patients to make up for an expected 15% loss of patients due to dropouts for a final study population of 353 patients. Based on a patient flow analysis we calculated to be able to complete recruitment in 30 months. All patients admitted to ER with a diagnosis of DRF were considered for recruitment in the study protocol if they met the following inclusion criteria: age ≥18 yrs; indication to conservative (nonoperative) treatment; displaced fracture requiring manipulation, patient's consent. Exclusion criteria were as follows: skeletally immature patient (age <18 yrs); undisplaced fracture not requiring manipulation; fracture requiring ORIF (e.g. Goyrand fractures); open fracture; any hand/wrist/forehand skin lesion on fractured limb; any vascular or neurological deficit; bilateral fracture; any association with homolateral upper limb fracture. Patient with any kind of medical comorbidities were included in the study; Patients exited the study (dropouts) when satisfactory reduction could not be achieved at first or second attempt (according to Graham's criteria), cast had been damaged or removed during treatment, or if they withdrew the consent (11). Software random allocation in blocks of 4 resulted in 353 sequentially numbered, opaque sealed envelopes. This was done by a statistician with no involvement in clinical care of patients. Radiographic measurements were all performed by a single investigator who was not involved in patient recruitment and was blinded to patient group assignement. Statistiscal analysis were carried out by statistician who was blinded to group assignement (BEC vs AEC). When a patient was eligible for enrollment and gave written consent to recruitment upon clear explanation of the study protocol, the treating physician opened an envelope and assigned the patient to the treating group. Closed manipulation of the displaced fractured was performed under local anaesthesia (haematoma block with 5-10 ml of mepivacaine 2%); the forearm was immobilized in opposite-to-the-dislocation position or neutral position in the case of severe metaphyseal comminution without angular deformity. Standard arm cast was a radial gutter manufactured using plaster of Paris. None of the fractures were treated in an operating room or using a C-arm image intensifier. Patient assigned to BEC group were treated with a below-elbow cast extending from the metacarpal heads to 2-4 cm from the elbow. Patient assigned to AEC group were treated with an above-elbow cast extending from the metacarpal heads to midway of the arm. X-rays (PA and LL views) were taken prior and after manipulation, at 7 and 35 days. The radial gutter was closed at first office

visit and removed at the final one. Radiographic parameters were determined for each x-ray examination from the time of injury to the end of treatment. Radial length (RL) was measured on the PA view as the distance between two lines drawn perpendicular to the radial shaft's long axis: one line was drawn at the tip of radial styloid and the other line was drawn at the ulnar border of radius articular surface at the central reference point (12). Radial inclination (RI) was measured on the PA view by determining the angle between a line passing through the tip of the radial styloid and the medial corner of the articular surface of the radius and a line perpendicular to the shaft ofthe radius. Volar tilt (VT) was measured on the LL view by the angle between the line of the distal articular surface (a line passing through the two most distal points of the dorsal and volar lips of the radius) and a line perpendicular to the longitudinal axis of the radius (Fig. 1, 2, 3). Fracture stability was assessed according to Lafontaine (dorsal angulation >20°, dorsal comminution, articular involvement, associated ulnar fracture, age >60 years) on pre-treatment radiographs: if three or more of these criteria were present, the fracture was defined as unstable (13). Cast index was determined, as described by Chess on post-reduction radiographs,

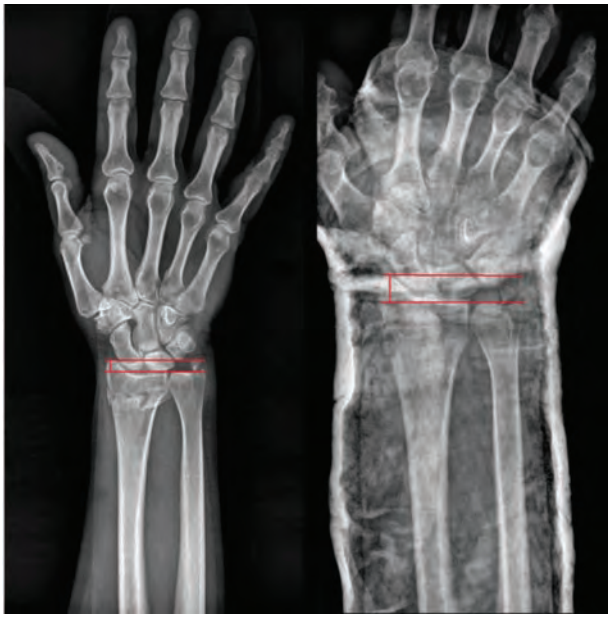

Figure 1. Radial Height measurement before and after reduction

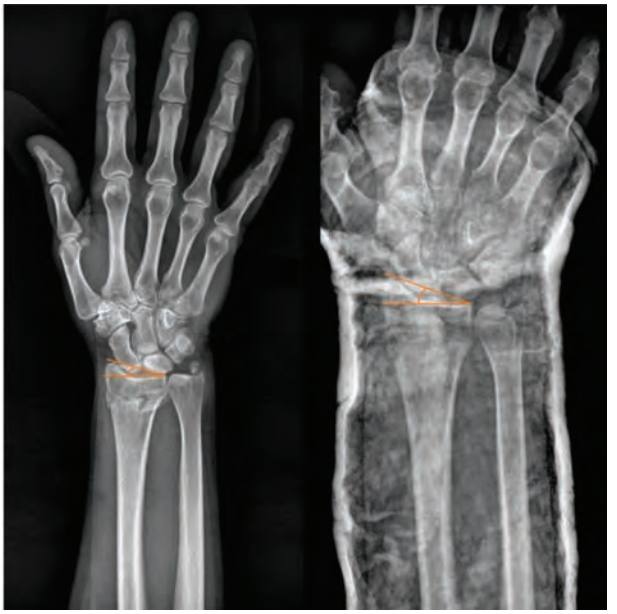

Figure 2. Radial Inclination measurement before and after reduction

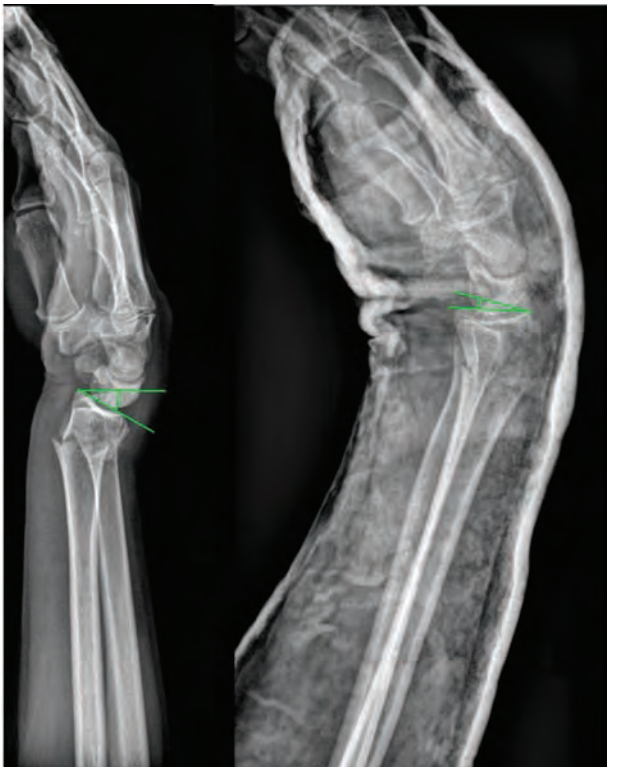

Figure 3. Volar Tilt measurement before and after reduction

as the ratio between the cast widths measured respectively on LL view and on PA view (14). Maintenance of reduction was considered acceptable when it met the following criteria described by Graham: loss of radial length <5 mm, radial inclination ≥15°, volar tilt between +15 and −20°. Patients were stratified by age, sex, presence of osteoporosis (indirectly assessed by osteoporosis-specifc drug consumption), fracture type (according AO classification) and fracture stability (according Lafontaine's criteria) (11, 13, 15). Protocol details are also available on https://clinicaltrials.gov/ct2/show/NCT03468023.

Statistical analysis

For comparisons of single continuous variables T-tests were used, for categorical variables the Chi-squared test (α=0,05) was used. To test the association of more than one variable simultaneously on dicotomicous variables a logistic model was performed. For continuous variables an ANCOVA model was used.

Table 1. Dropouts and patients excluded from analysis. No statistical difference between the treatment groups (Fisher test=0.96, pvalue>0.05)

	Treatment		
	BEC	AEC	Total
Dropout			
Skin lesion occured during manipulation		1	1
Manipulation unsuccesful	9	8	10
Cast damaged/removed	5	7	12
Excluded from analysis			
Enrolled by mistake	3	3	6
Lost to followup	3	1	4
Tot	**20**	**20**	**40**

Results

Patient population and treatment assignement

One-hundred-sixty-two patients were recruited from March 2017 to June 2018. Of these, 140 have completed followup and were considered for analysis. Six patients have been enrolled by mistake (they were found not to meet inclusion/exclusion criteria), 4 were lost to follow up, 30 were dropouts (Tab. 1). Patients included in this analysis were 100 of which 50 patients assigned to BEC group and 50 patients to AEC group. Patients excluded from analysis were homogeneously distributed among the two treatment groups, leaving the remaining data sufficiently unbiased to undergo further statistical anaysis (Table 1). Demographic and baseline characteristics were again homogeneously distributed among the two groups. There are no significant differences in sex, age, fracture type, osteoporosis, fracture stability. Characteristics of patients by treatment group are summarized in Table 2. Chi-squared tests were performed to test each variable association with treatment, none of them is significant (assuming α=0.05). We additionally performed a logistic model to test the association between all pretreatment variables and group assignement. No variables have been found to be statistically associated to treatment group assignement (α=0.05).

Radiographic parameters

Mean time of cast immobilization for patients included in the analysis treated with a below-elbow cast was 32,1 days (5-56 days), for patients treated with an above-elbow cast was 31 days (39-7 days). Radiographic parameters are summarized in Table 3. T-test between treatment groups at baseline did not show any statistically significant difference (α=0,05). Baseline radiographic parameters were measured on post-reduction xray taken on the day of enrollment in the study and compared with those measured on final xray taken on the last followup visit

Non inferiority thresholds

For each radiographic parameter we compared post reduction measurements with baselines values for each patient (Δ), then we calculated treatment groups means and the difference between them. An example of the formulas used for Radial Length (group A is BEC, group B is AEC):

$$\Delta_{RL} = RL_{post-reduction} - RL_{baseline}$$

$$raw\ diff = group\ A\ mean(\Delta_{RL}) - group\ B\ mean(\Delta_{RL})$$

Table 2. Characteristics of patients by treatment group. Randomization created two homogeneous groups by major confounders (sex, age, AO type, osteoporosis and stability)

	BEC (n=50)	AEC (n=50)	Chi-square test, p-value
Sex			p=0,56440
Male	6 (12%)	8 (16%)	
Female	44 (88%)	42 (84%)	
Age			p=0.7180
yrs (CI 95%)	70 (66,1-74,1)	68 (63,9-72,6)	
AO Type			p=0.2640
A	30 (60%)	25 (50%)	
B	0 (0%)	2 (4%)	
C	20 (40%)	23 (46%)	
Osteoporosis			p=0.6870
Yes	21 (42%)	23 (46%)	
No	29 (58%)	27 (54%)	
Stability (La Fontaine criteria)			p=0.6892
Stable	26 (52%)	24 (48%)	
Unstable	24 (48%)	26 (52%)	

Table 3. Radiographic parameters measured at baseline a final xray, divided by treatment group. We reported mean values and 95% confidence Intervals. For all variables confidence intervals overlap

	BEC (mean [95% CI])	**AEC (mean [95% CI])**
Baseline Xray		
Radial height (mm)	10,8 [10,3; 11,4]	11,5 [11,1; 12]
Radial inclination (°)	20,5 [19,4; 21,5]	22 [21,1; 22,8]
Volar tilt (°)	-7,6 [-9,4; -5,8]	-6,6 [-8,1; -5]
Final Xray		
Radial height (mm)	9,3 [8,7; 9,9]	10,2 [9,6; 10,7]
Radial inclination (°)	17,8 [16,8; 18,8]	20,2 [19,3; 21,1]
Volar tilt (°)	-3,7 [-6,7; -0,7]	-2,1 [-4; -0,1]

Table 4. Differences between AEC and BEC group calculated raw or with ANCOVA models corrected by measurable confounders

	Raw difference post reduction variables[1]	Difference corrected by all variables[2]	Difference corrected by	Non-inferiority threshold
Radial length	0.04	0.18	0.16	2 mm
Radial inclination	0.7	0.78	0.94	3°
Volar tilt	0.18	0.15	0.24	3°

[1] Variables included as covariates in the ANCOVA model: cast index, reduction quality and cast quality.

[2] Variables included as covariates in the ANCOVA model: cast index, reduction quality and cast quality, days to final followup, AO Type, sex, osteoporosis, stability, age

Taking into account raw data, patients in BEC group lost 1,75 mm of RH, 2,9° of RI and 4,5° of VT over the course of cast immobilization. Patients in AEC group lost 1,71 mm of RH, 2,2° of RI and 4,8° of VT. For all radiographic parameters we obtained raw differences between groups. In order to control for possible bias due to measured variables we corrected these differences using an ANCOVA model for post reduction (cast index, reduction quality and cast quality) and pre reduction variables (sex, age, fracture type, osteoporosis, fracture stability). Results are summarized in Table 4. Values are reported in comparison with non-inferiority thresholds used in the SLAVER protocol: all differences are below the correspondent threshold. Raw differences between average loss of RH, RI, VT during treatment between the two groups were respectively 0,04 mm, 0,7° and 0,3°.

Discussion

Distal radius fractures represent a common clinical challenge in the everyday practice of an orthopaedic trauma department.

The absence of a consensus strategy has negative implications for the management of these common lesions, particularly in terms of quality of care and highest patient comfort.

Currently, there is no general agreement on how to immobilize a DRF. Various methods have been described, but no one approach has been proved more effective than the others.

Sarmiento in 1975 and later Bünger in 1984 proposed the use of a long-arm cast to lock the forearm in supination to neutralize the brachioradialis muscle, which was considered responsible for loosing reduction. Based on electromiographic studies, Sarmiento argued that immobilizing the wrist in supination, with brachioradialis in a resting position, would minimize the muscle influence on fracture displacement (3, 5). Wahlstrom proposed the pronator quadratus muscle as a major deforming force, thus suggesting locking the wrist in pronation (6). This was based on the assumption that even minimal movements of the distal radio-ulnar joint could endanger the maintenance of-reduction. However, there is no evidence that locking prono-supination plays a role in maintaining reduction. Indeed, many prospective randomized trials have failed to support this theory, concluding that there is no difference in the risk of secondary displacement with or without elbow immobilization (16-21). However, most of these reports were biased and lacking statistical evidence, thus preventing clinicians from putting these findings into practice. In 2003, a Cochrane review concluded that there was insufficient evidence to make any recommendations as to what is the best conservative treatment for DRFs (22).

A previous retrospective study conducted at our institution did not show any difference in rate of secondary displacement in DRFs managed either with BEC or AEC. We observed that average difference in reduction maintenance probability between the two groups at 35 days was 1.2%. This finding led us to hypothesize that the two treatments were substantially equal (23). However, case series studies result in only level III clinical evidence which is insufficient to draw scientifically sound conclusions.

SLAVER was designed to further support the hypothesis that type of cast does not affect the likelihood of secondary displacement in conservatively managed DRFs. We planned this study as a non-inferiority trial, hence we established non-inferiority thresholds as described above. If any study outcome variable (namely, RH, RI, VT) was not above the non inferiority threshold one could reasonably assume that no actual difference exist. Likewise, if 95% confidence intervals overlapped no difference between groups is assumed. Quality of randomization was checked with chi-square tests and logistic models to make sure no variables were associated with patient group assignement. To remove any confounding variable and ensure study variable was dependant solely on type of cast, ANCOVA models were used to correct results by all confounding variables. These preliminary results show that the difference of loss of RH, RI and VT between the two groups are all below the non-inferiority thresholds: the two treatments did not differ for more than 2 mm of loss for radial height, 3° of loss for radial inclination and volar tilt. This would indicate a possible clinical equivalence of the two treatments. However, sample size is not large enough to achieve statistical significance.

Currently, two more RCTs on the same topic are underway in Brasil and North America (24, 25).

The best conservative treatment of DRFs remains still to be understood. Results from our RCT along with the brasilian and north american RCTs will help provide additional evidence on the role of cast length to treat DRFs in the hope of moving closer to high quality guidelines.

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Original article

Preliminary experience with triangular CarboFix "Piccolo" Distal Radius Plate in wrist fractures. Clinical and radiological results

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Summary. *Background and aim o the work:* In the recent last years there was a diffusion of new radiolucent plates for the treatment of distal radius fractures. The aim of our study is to evaluate the clinical and radiological outcomes at 12-month-follow-up for the treatment of distal radius fracture with the new triangular CarboFix "Piccolo" Distal Radius Plate. *Methods:* All consecutive patients aged from 18 or over, who were treated for unstable distal radius fracture with a volar CarboFix "Piccolo" Distal Radius Plate with triangular design between September 2015 and May 2016, have been included in the study. From the original 28 patients, 6 patients were lost to the follow up or did not meet the inclusion criteria and 22 were available for the study. The 22 patients were prospectively reviewed with dynamometric, radiographic and clinical evaluations (ROM, VAS, Quick DASH). *Results:* The mean follow-up was 15.7 months. All fractures healed, and radiographic union was observed at an average of 5 weeks. All patients have recovery of R.O.M. comparable to the contralateral at the final follow up; with no significant difference ($p>0.05$) as regards extension, flexion, ulnar deviation, radial deviation, supination and pronation comparing to the unaffected arm. At final follow-up, no patients had a statistically significant difference ($p>0.05$) of grip strength, comparing to the contralateral side. The mean Quick DASH was 9.3 and the mean VAS score was 2.3. *Conclusion:* The most important finding of the present study was that the triangular CarboFix "Piccolo" Distal Radius Plate showed good clinical and radiological results in the treatment of distal radial fractures. These results are comparable to those achieved with conventional plates. (www.actabiomedica.it)

Key words: distal radius fractures, carbon-PEEK, fixation devices

Introduction

Fracture of the distal radius and ulna is the most common fracture encountered by orthopaedic trauma surgeons accounting for 17.5% of all adult fractures with around 120,000 fractures per year in the United Kingdom and 607,000 annually in the United States (1, 2).

It would seem therefore that the incidence of fractures of the distal radius is increasing in men and older women but remains more common in older women (2).

Open reduction and internal fixation with plating is the leading technique for stabilizing fractures of the distal radius. Plating was first popularized for volar displaced distal radial fractures by Ellis in 1965 with a plate which was placed on the volar surface of the radius and acted as a buttress to prevent volar displacement of the distal fragment (3)

Volar locking plates were then introduced to stabilize dorsally displaced fractures. As fixed angle devices, theoretically volar locked plates provide sufficient stability to the dorsally displaced distal fragments (4).

In the few last years some authors described the use of radiolucent plate in the treatment of distal radial fractures surgically treated (5, 6).

These plates are made of 70% of longitudinal and diagonal continuous carbon fibre-reinforced with 30% of polyetheretherketone (CFR - PEEK) (7). This material gives to the osteosynthesis device a radiolucent X-ray property, associated with no artefacts during CT and MRI scans, that enables good visibility through the plate during surgery and follow-up (8). This Composite Material mimics the cortical bone's Modulus of Elasticity (9) with good mechanical properties. As well there are no cold welding events with titanium screws.

Moreover, from their introduction, new designs of carbon plates were introduced to better comply the anatomical reduction and stable fixation and to reduce the hardware complications that represent the majority of complications, ranging from 5.9% to 48% (10-12).

The aim of our study is to evaluate the clinical and radiological outcomes at 12-month-follow-up for the treatment of distal radius fracture with the new triangular CarboFix "Piccolo" Distal Radius Plate.

Methods

All consecutive patients aged from 18 or over, who were treated for unstable distal radius fracture with a volar CarboFix "Piccolo" Distal Radius Plate with triangular design between September 2015 and May 2016, have been included in the study.

The new volar CarboFix "Piccolo" Distal Radius Plates have some advantages: in the smaller size the width is lesser then conventional plate in order to better fit the smaller radius, they are longer than the conventional model with a more anatomical design, all the distal screws are angular stability screws with 10° of poliaxiality and there are more holes for the provisional stabilization with K wires.

Exclusion criteria were: previous fracture of the wrist and carpus, previous local and general infective disease, age <18 years old and previous surgery on the index wrist. The study protocol was approved by the hospital's Ethical Review Board and it was conducted in accordance with the principles of the Declaration of Helsinki and its amendments. We fully informed all the Subjects about the characteristics of the study and they gave their consent.

From the original 28 patients, 6 patients were lost to the follow up or did not meet the inclusion criteria and 22 were available for the study. The 22 patients [8 men and 14 women; mean age (standard deviation, SD)=50.8 (10.34)]; were treated with the triangular carbon plate according to the choice of the surgeon in accordance with all patients.

All patients were prospectively reviewed with radiographic and clinical evaluations.

Clinical evaluation

All patients were evaluated at a minimum follow up of 12 months with: active and passive ranges of wrist motion (ROM), Quick Shoulder and Hand score (Quick-DASH) and the Visual Analog Scale (VAS). Grip strength was measured with a Jamar® dynamometer evaluating Hand Grip and Key Pinch. Grip strength, Hand Grip (HG) and Key Pinch (KP) of the uninjured side was used as control.

In addition, the patients were asked to state at which post-operative time they were able to return to their normal daily activities.

Radiographic evaluation

We performed posterior-anterior (PA) and lateral (LL) x-ray at time of injury and postoperatively (Figure 1). A standardized radiological assessment was performed postoperatively at one month, three months, six months and 12 months after surgery. The evaluation was made by the same expert observer. We recorded: radial height, radial inclination, volar tilt and ulnar variance both preoperatively and postoperatively in order to estimate correction values. We also considered postoperative articular step-off persistence.

Surgical Technique

The surgical technique was the same for all patients.

The patient is placed supine and the arm abducted to 90 degrees, supinated, and placed on an arm

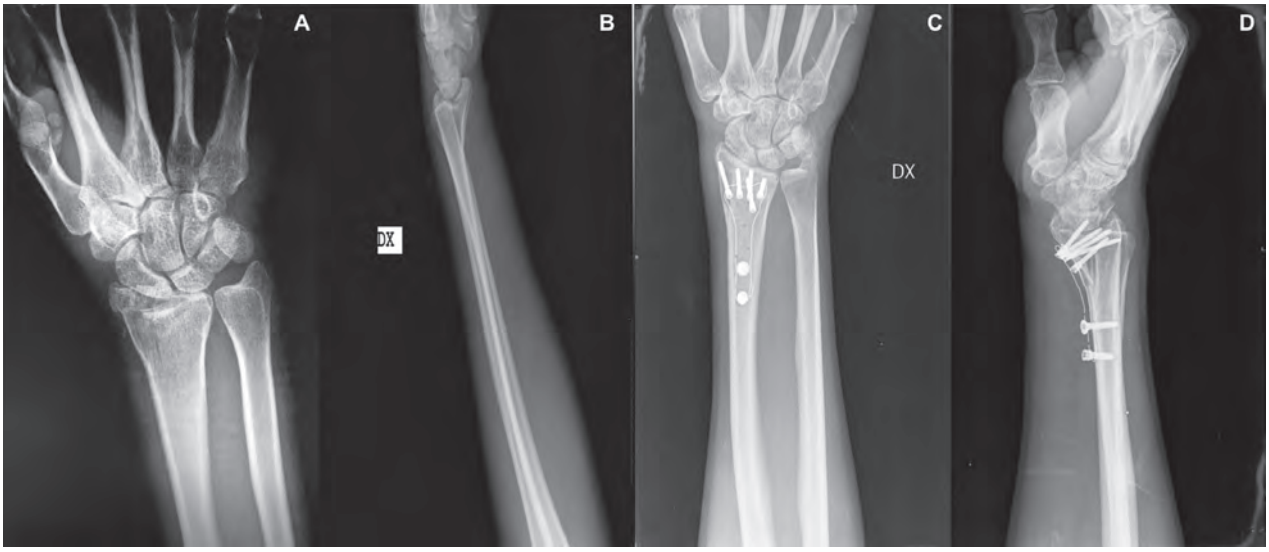

Figure 1. A, B: Pre operative trauma series of a distal radius fracture. **C, D:** Post operative X-ray of a distal radius fracture treated with a radiolucent triangular plate

table. A tourniquet is applied to the upper arm. The surgeon sits in the axilla and the C-arm is positioned diagonally from the opposite side of the arm table. The approach is the modified Henry's approach. A longitudinal skin incision is used in line with the flexor carpi radialis (FCR) tendon. The fascia is released to expose the FCR tendon, which is mobilized by incising the sheath. The tendon is then retracted in an ulnar direction and an incision made in the floor of the tendons heath. This exposes the flexor pollicis longus (FPL) muscle belly, which is swept to the ulnar side by blunt dissection. The transverse muscle fibers of pronator quadratus are then evident and should be released from the radial side of the radius and elevated subperiosteally from the radius in a volar direction to expose the fracture. Reduction is achieved with pointed reduction clamps. Plate is selected of sufficient length and fixed with screws.

Postoperative Rehabilitation

Immediately after surgery, the patient was encouraged to elevate the hand and begin early finger motion. A short arm plaster splinting was maintained for 2 weeks until the first follow-up visit. At that visit, the dressings and sutures were removed, radiographs were taken, and therapy was started under the supervision of a certified physiotherapist. A prefabricated orthosis was also applied for comfort and protection for further 2 weeks. During weeks 2 through 6, an antiedema protocol was started along with tendon gliding and range of motion exercises.

Statistical Analysis

Statistical Package for social Sciences (SPSS) version 22 was used for calculations. All the data were analyzed by a single blinded researcher. Computed *P* values were two-sided, and $P<0.05$ was used to determine statistical significance. The Wilcoxon-Mann-Whitney test for two independent samples was performed in order to evaluate differences for numerical variables.

Results

All fractures healed, and radiographic union was observed at an average of 5 weeks (range 4-8 weeks). No cases of loss of the surgically achieved fracture reduction were documented.

The mean follow-up was 15.7 months (range 12-19 months). Mean wrist range of motion, assessed

with a goniometer, resulted as follows: 65° of extension (range 54°-76°), 78° of flexion (range 72°-80°), 18° of radial deviation (range 15°-20°), 39° of ulnar deviation (range 35°-45°), 87° of supination (range 82°-90°) and no patients showed loss of pronation at follow-up (80°).

All patients have recovery of R.O.M. comparable to the contralateral at the final follow up; with no significant difference ($p>0.05$) as regards extension, flexion, ulnar deviation, radial deviation, supination and pronation comparing to the unaffected arm.

At final follow-up, no patients had a statistically significant difference ($p>0.05$) of grip strength, evaluating Hand Grip (HG) and Key Pinch (KP) comparing to the contralateral side. On average, the HG was 92.3% (mean value 19.5 Kg, range 11.2-33.6 Kg) and KP was 90.4% (mean value 8.1 Kg, range 2.3-16.7 Kg) of the unaffected extremity.

The mean score on the Quick DASH was 9.3 (range 2.5-15.9). Patients were able to return to their normal activities of daily living at an average of 4.2 weeks (range 3-8.4 weeks) post-op. Finally, mean VAS score was 2.3 (range 0-3.5).

Articular step-off persistence was assessed in 18.3% of patients. Normal radial inclination (21°-25°) was restored in 78.5% of patients (range 15°-27.5°). Normal radial height (10 mm-13 mm) was restored in 70.6% of patients (range 6.8 mm-7.3 mm). Normal volar tilt (7°-15°) was achieved in 93.2% of patients (range 3°-187°). Normal ulnar variance (0.7 mm-1.5 mm) was restored in 89.5% of patients (range 0.7 mm-4.1 mm). The statistical analysis has shown a significant difference between the pre-operative and post-operative radiographic values (p value <0.01).

No cases of hardware failure, loss of position or alignment of locking screws, nervous complications, infection or allergy to the plate were observed in our cohort of patients.

Complications

In one case, a 43-year-old male, clinical signs of extensor tendons synovitis were reported 6 months after surgery. Radiographs revealed an excessive length of one screw of the distal branch of the plate, after which the plate and the screws were removed. Intraoperative hardware integration was found to be limited, facilitating, therefore, removal of the plate.

Discussion

The most important finding of the present study was that the triangular CarboFix "Piccolo" Distal Radius Plate showed good clinical and radiological results in the treatment of distal radial fractures.

Comparing our results with literature, the overall clinical results obtained with the use of the new triangular carbon plates at 12-month follow-up are consistent with the recent findings using conventional metal plates (13-18).

Despite data showed a substantial equivalence, the triangular CFR-PEEK plates have some potential advantages that may support their introduction into clinical practice (19). In fact, this material gives to the fixation device a radiolucent X-ray property, with no artifacts during CT and MRI scans, and enables good visibility through the plate during surgery and follow-up (8, 20, 21).

In fact, the authors of a recent study (20) showed that a volar distal radius plate made from CFR-PEEK has minimal effect on bone parameters obtained at the distal radius with high-resolution peripheral quantitative computed tomography. So they recommend the use of CFR-PEEK plates instead of conventional titanium plates to monitor the healing process of distal radius fractures.

This composite material mimics the cortical bone's Modulus of Elasticity (9) with good mechanical properties. As well there are no cold welding events with titanium screws (6).

These advantages are well described by Tarallo at al. (6) in a recent publication.

The authors showed the results of 12 months follow up of carbon-PEEK plates for the treatment of distal radius fracture.

Also in this paper, the Authors reported good clinical and radiological outcomes without any significant complication in a cohort of 40 patients treated with carbon-PEEK plates.

In our experience, the triangular CarboFix "Piccolo" Distal Radius Plate helps surgeons in their work by enabling good observation of the fracture during

reduction and healing and it is associated with rapid fracture healing. This was emphasized by the current study in which all patients showed radiographic healing at an average of 5 weeks follow-up.

In only one case the triangular CarboFix "Piccolo" Distal Radius Plate was removed without complications.

However, this study has some limitations. The number of patients is small and the follow-up period was short, however it is a preliminary report from a single center.

Finally, the present study is a case series without a control group, but to our knowledge, this is the first study to report prospective clinical and radiographic outcomes after fixation of a distal radius fracture with a CFR-PEEK triangular plate and future case control studies should be performed to compare these new CFR-PEEK triangular plates with the conventional titanium plates.

Conclusion

Fixation of the distal radius fractures with a triangular CarboFix "Piccolo" plate provides satisfying clinical and radiographic results after 1 year of follow-up.

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Original article

When is indicated viscosupplementation in hip osteoarthritis?

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Summary. *Background and aim:* The incidence of hip osteoarthritis (OA) is increasing in parallel with the aging of the population. The aim of this study is to report the efficacy of an ultrasound-guided intra-articular (IA) hip injection of a single dose of high-weight hyaluronic acid (HA) (2500 kDa) at a follow-up of 12 months. *Materials and Methods:* 226 patients older than 40 years of age affected by painful hip OA (Kellgren-Lawrence stage 1-2-3) were treated from January 2012 to December 2015 with viscosupplementation. Patients were clinically evaluated before injection (T0) and after 3 months (T3), 6 months (T6) and 1 year (T3) through the WOMAC scale and Harris Hip Score (HHS). *Results:* During the follow-up period no patients underwent to hip surgery or need adjunctive IA injection of HA. No adverse effects were registered. An improvement in WOMAC and HHS was observed in all patients after treatment. Results showed that patients with grade 2 of osteoarthritis had the higher delta of change in the scores. *Discussion:* Ultrasound-guided with high weight IA HA injection could be a possibility of treatment in the symptomatic osteoarthritic hip. Subjects with a moderate grade of osteoarthritis (Kellgren-Lawrence stage 2) represent the group that could report the maximum benefits from viscosupplementation. (www.actabiomedica.it)

Key words: hip, osteoarthritis, viscosupplementation, hyaluronic acid, ultrasound

Introduction

Hip pain, which could be the consequence of different pathologies, is reported by 19.2% [95% confidence interval (CI) 17.9-20.6] of people aged 65 years and older (1-3). The incidence of hip OA is increasing in parallel with the aging of the population and is estimated at between 47.3 (95% CI 27.8-66.8) (4) and 88/100 000 patient-years (95% CI 65-101) (5). Optimal management of this disease requires a combination of non-pharmacological and pharmacological modalities, thus delaying or avoiding surgical treatments (osteotomy and/or total hip prosthesis) (6-10). HA was initially isolated in 1934 by Karl Meyer in the vitreous humor. It is a polysaccharide macromolecule, a glycosaminoglycan of high molecular weight (MW) composed of repetitions of disaccharides of glucuronic acid and N-acetylglucosamine; it is a constituent of synovial fluid in normal joints and is synthesized by chondrocytes and synoviocytes (5). HA has complex biological properties that could explain its analgesic effects (anti-inflammatory by inhibiting the formation and release of prostaglandin, immunomodulatory in situ), irrespective of its mechanical action on the joint fluid. The concentration of HA in an arthritic joint has been found to decrease to 50-33% of normal levels, and includes a reduction in molecular size with a consequent decrease in elasticity and viscosity of the synovial fluid (11). In 1997 HA received Food and Drug Administration (FDA) approval in humans and it was

initially used in the treatment of knee OA. This procedure should improve the physiological environment of an osteoarthritic joint by restoring its protective viscoelasticity (12-15), reducing friction and improving mobility (16, 17). Intra-articular hip injections have been attempted for a wide variety of hip disorders, including OA, rheumatoid arthritis (18), acetabular labral tears, and femoral-acetabular impingement (19, 20). The injection of hyaluronic acid in the joint space allows to reach a high and durable concentration with low doses. Evidences suggest that this is the best conservative therapy for hip OA before surgery, and it can act on pain relief without modifying the morphological structure of the pathological hip and natural history of the disease. However, there is no general consensus on number and timing of hip injections and type of HA to be used. The aim of this study is to analyze the efficacy and safety of ultrasound-guided IA injection of a single dose of high-weight HA (2500 kDa) in patients affected by hip OA at a follow-up of 12 months.

Materials and Methods

This study was conducted in accordance with the principles of Declaration of Helsinki. All patients signed informed consent about the treatment they were subjected and the processing of their personal data.

Patients treated from January 2012 to December 2017 with an ultrasound-guided IA injection of high weight HA (figure 1) for hip osteoarthritis were scheduled for the present study.

Inclusion criteria were also age more than 40 years, mono- or bilateral hip OA with X-ray proof of at least partially preserved joint space (Kellgren-Lawrence stage 1-2-3) (21), good or full joint mobility, and hip disease persisting for at least 3 months. Exclusion criteria were: the presence of severe hip OA for which it was no longer possible to recognize radiographic joint space (Kellgren-Lawrence stage 4), of inflammatory, autoimmune and septic disease and of previous hip surgeries. All patients received a single high-weight (2500 kDa) injection of 2.5% sodium hyaluronate (60 mg/4 mL).

All procedures were performed with an ultrasound guidance in accordance with the technique

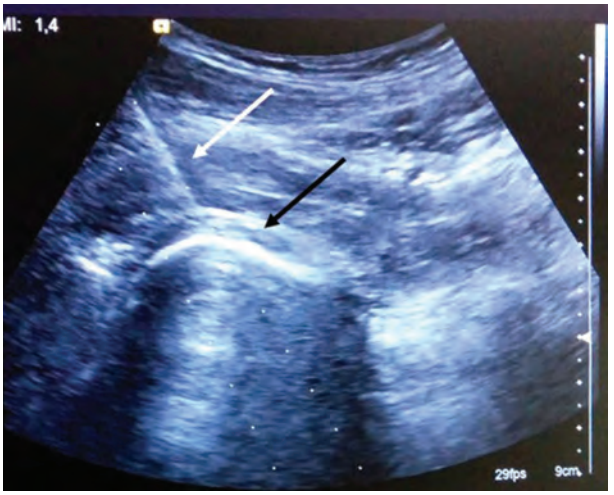


Figure 1. Ultrasound image with needle (white arrow) around the femoral head (black arrow)

suggested by Migliore et al. (22). All subjects were clinically evaluated before injection (T0) and after 3 months (T3), 6 months (T6) and 1 years (T12) utilizing the WOMAC scale and HHS.

Results were considered for statistical analysis, which was performed with JASP (software 0.7.5). At each study time, mean, standard deviation and median endpoints were calculated. For the same endpoint, comparisons were made at different study times using Student's t test for paired samples. Moreover, statistical comparisons were performed for the different groups of patients with different grade of osteoarthritis. Results were considered statistically significant for values of $p<0.05$.

Results

Overall, 226 subjects (135 female and 91 male) were included for the analysis of the data. The mean age was 64.2 years (SD 9.82, range 42-85) and the mean BMI was 25.8 (SD 3.66, range 18.25-32.95). Considering Kellgren-Lawrence classification 35 patients showed a Grade I of OA, 104 a Grade 2 and 87 a Grade III.

The results of WOMAC scale and HHS at T0, T3, T6 and T12 are summarized in table 1 and 2 and graph 1 and 2.

Table 1. WOMAC results at T0, T3, T6 and T12

	WOMAC_T0	WOMAC_T3	WOMAC_T6	WOMAC_T12
Valid	74	74	74	74
Missing	0	0	0	0
Mean	62.20	52.86	48.05	50.34
Std. Error of Mean	1.973	1.782	1.780	2.017
Median	65.00	52.50	45.00	47.50
Mode	72.00	31.00	28.00	35.00
Std. Deviation	16.97	15.33	15.31	17.35
Skewness	-0.2059	0.1181	0.2398	0.3094
Std. Error of Skewness	0.2792	0.2792	0.2792	0.2792
Kurtosis	-1.258	-0.8432	-0.8696	-1.003
Std. Error of Kurtosis	0.5517	0.5517	0.5517	0.5517
Minimum	33.00	26.00	23.00	21.00
Maximum	88.00	85.00	78.00	84.00

Table 2. HHS results at T0, T3, T6 and T12

	HHS_T0	HHS_T3	HHS_T6	HHS_T12
Valid	74	74	74	74
Missing	0	0	0	0
Mean	57.36	70.16	75.13	72.50
Std. Error of Mean	1.716	1.646	1.515	1.710
Median	62.00	73.41	80.50	77.00
Mode	72.00	84.00	87.00	84.00
Std. Deviation	14.76	14.16	13.03	14.71
Skewness	-0.5273	-0.7459	-0.9825	-0.9874
Std. Error of Skewness	0.2792	0.2792	0.2792	0.2792
Kurtosis	-0.9889	-0.4125	0.03261	0.1737
Std. Error of Kurtosis	0.5517	0.5517	0.5517	0.5517
Minimum	24.80	35.20	41.65	35.20
Maximum	73.15	87.00	90.00	90.00

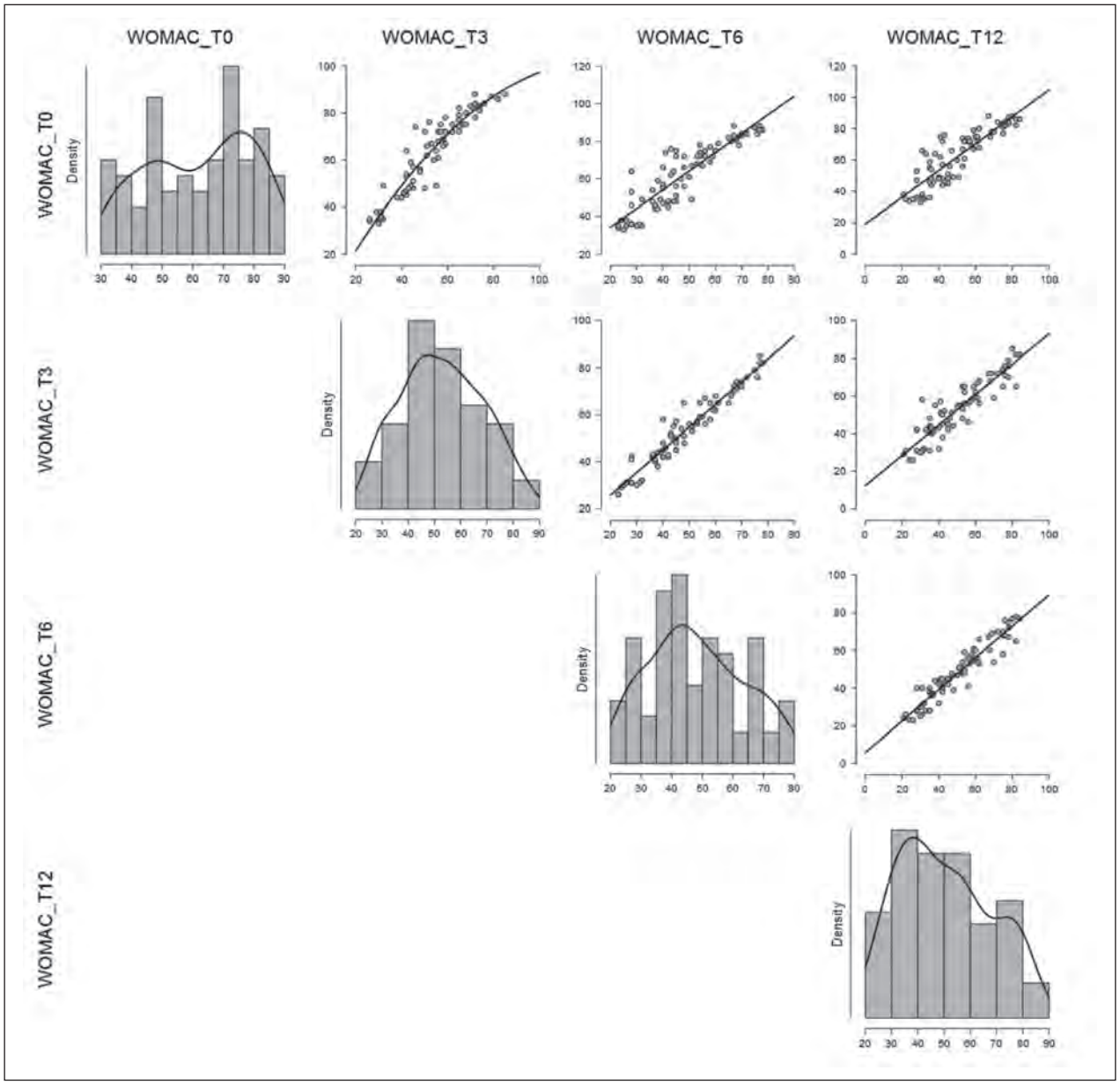
Statistical analysis showed significant improvements for WOMAC scale and HHS between results before (T0) and after HA injection (T3, T6 and T12) ($p<0.001$).

No patients had adverse effects, underwent to other surgical procedures and/or need adjunctive IA injection of HA.

For each group of Kellgren-Lawrence classification a separate analysis was performed and the scores were separately calculated (graph 3 and 4). Considering the delta of change between T0 and T3 for WOMAC and Harris Hip Score, the higher was documented in patients with grade 2 of osteoarthritis.

Discussion

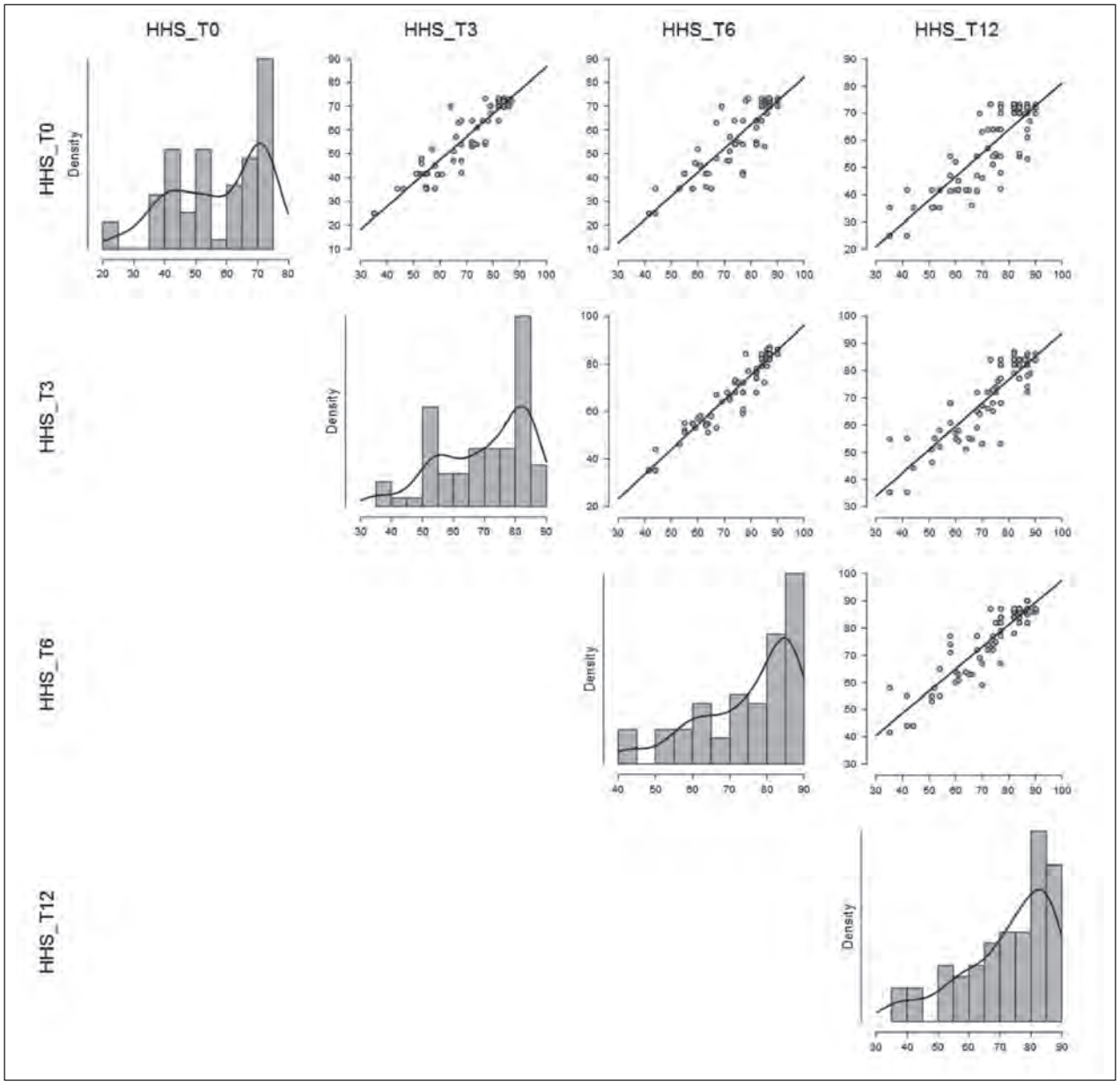
OA can affect all the synovial joints, but knee and hip are the most frequent localizations. Although its incidence is higher in elderly, this pathology is also observed in young adults, especially in the case of intense sporting and working activities and following articular pelvic fractures (22). It is estimated that 25-30% of the population over 45 years of age is affected by a form of OA. Hyaluronic acid plays an important role in lubrication, shock absorption and visco-elastic behaviour of synovial fluid, whose rheological properties confer the characteristic of reducing mechanical stress on the joint (23).



Graph 1. Density of WOMAC global scores

At the beginning of the 90s, the Hungarian doctor Endre Alexander Balazs hypothesized that infiltrations with exogenous hyaluronic acid in patients suffering from OA could restore the visco-elasticity of the synovial fluid (11).

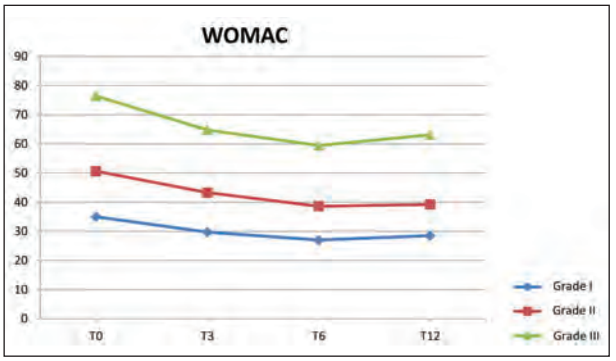
The concept of viscosupplementation was subsequently developed because of the scientific evidence that the rheological properties of the synovial fluid were altered in OA and that these changes were related to the qualitative modification and quantitative decrease of hyaluronic acid (14). It has been demonstrated that infiltrations with hyaluronic acid are effective in this pathology, thus determining the control of pain and improving joint function (20). In addition, exogenous derivatives seem to have biological activities such as the induction of endogenous high molecular weight hyaluronic acid synthesis, interaction with pain receptors and inhibition of pro-inflammatory media-



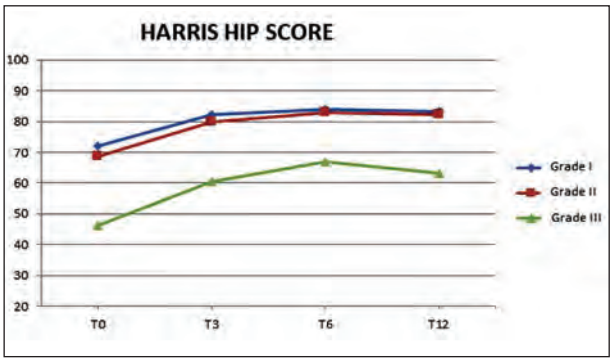
Graph 2. Density of HHS global scores

tors (11). Lùrati et al. (25) studied the effects of HA viscosupplementation on peripheral T cells in knee and hip OA and they showed that HA injection results in a decrease in proinflammatory T cells concentrations. In particular, HA can reduce synovial inflammation and restore the rheological properties of synovial fluid.

The significant results obtained in the infiltrative treatment of other degenerative joint diseases, such as knee OA (24), have led the scientific community to identify new reliable therapeutic patterns also for symptomatic osteoarthritis of the hip. Even if hip viscosupplementation is certainly characterized by a greater technical difficulty than the knee one, given the deep anatomical position of the joint and the presence of the femoral vascular-nervous bundle that require the preferential use of an ultrasound guide, results for hip viscosupplementation are usually encouraging. Dallari et al. (26) compared Platelet Rich Plasma (PRP)



Graph 3. WOMAC scale results at T0, T3, T6 and T12 in different stages of OA



Graph 4. HHS results at T0, T3, T6 and T12 in different stages of OA

injections to HA or their association (PRP1HA) at 6 and 12 months follow-up. All intra-articular injections lead to a significant clinical and functional improvement, with no significant differences between the three methods of treatment. Battaglia et al. (27) combined HA and PRP injections following a specific protocol for moderate to severe hip OA (4 injections), and they performed VAS and radiological evaluation after 1, 3, 6 and 12 months. The results showed that in 93.7% of cases there was a significant reduction of subjective pain (VAS scores) but consumption of NSAIDs was greater in patients who received the combined therapy. Migliore et al. (22) compared HA injections to mepivacaine at 6 months follow-up (2 injections): patients in the HA group exhibited a significantly reduced Lequesne's algofunctional index and VAS at 3 and 6 months after treatment when compared with the local anesthetic group. Conrozier et al. (28) assessed the clinical response of patients presenting with symptomatic hip osteoarthritis to the first intra-articular HA injection at 3 months of follow-up (up to four injections according to symptoms). Clinical response was defined as a 50% reduction from baseline in the Lequesne index one month after treatment. The response rate was 50% after the first injection and about half of the patients experienced significant pain relief during the 3 months following a single injection, and some of the patients who did not respond to the first injection received significant benefit from a second one.

On the opposite, other results are not so well interpretable. Richette et al. (29) performed a single injection of HA or placebo. VAS and WOMAC were evaluated after 3 months and compared to baseline. The results showed that there was no significant difference in terms of efficacy after one injection of HA compared with placebo in patients with hip osteoarthritis. Furthermore, an ideal hyaluronic acid derivative, by molecular weight, density and duration of action, has not yet been identified.

Some Authors compared the efficacy of lower and higher molecular weight viscosupplementation in the treatment of hip OA.

Tikiz et al. (30) performed three hip injections (one injection per week), and evaluated VAS scale, WOMAC and Lequesne index after 1, 3 and 6 months. Both types of visco-supplementation produced a significant clinical improvement during the 6-month follow-up period, with no significant difference between higher and lower molecular weight hyaluronic acid. Atchia et al. (31) reported no significant improvement in pain and function after a single high molecular weight HA injection in low grade hip OA when compared to standard care with no injections or to saline or non animal stabilized HA. This suggests that high molecular weight hyaluronic acids may not have a role to play in low grade hip osteoarthritis.

The results of this study suggest that the use of a preparation with high molecular weight hyaluronic acid allows to obtain satisfactory improvements in pain and joint function with a single infiltration (32).

No patients had adverse effects, underwent to other surgical procedures and/or needs adjunctive IA injection of HA, thus demonstrating the validity and durability of the treatment over follow-up time.

However, several other therapeutic schemes are described which suggest the use of low or medium

molecular weight hyaluronic acid, with a higher frequency of infiltrative sessions. The results, in relation to different situations, are contrasting and not entirely appreciable (33).

As reported by the literature, in patients assessed with grade 1 Kellgren-Lawrence OA, the overall improvement twelve months after the infiltration is lower than that measured for grades 2 and 3 (34,35).

This study has several limitations which includes the low number of participants, the absence of a control group, the absence of a blinded methodology, the low duration of follow-up. However, this report proved the efficacy of ultrasound guided high weight IA HA injection for hip osteoarthritic treatment.

Conclusions

Authors can affirm that a single ultrasound-guided viscosupplementation with high weight IA HA injection could be a possibility in the symptomatic treatment of hip osteoarthritis. Subjects with a moderate grade of osteoarthritis seem to represent the group that could report the maximum benefits from the procedure.

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Original article

Mesenchymal Stem Cells injection in hip osteoarthritis: preliminary results

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Summary. *Background and aim of the work:* Osteoarthritis will become even more common in the near future since the average life span is steadily growing. Pain and loss of function are the main complaints reported by patients, inevitably leading towards a worsened daily life performance. New modern techniques have been developed with advanced cell based therapies. Mesenchymal stem cells (MSC) have the inner ability to mature into different types of cells depending on the stimuli they undergo. This technique has already been proven successful in the knee and, with this retrospective study, we would like to assess its feasibility in the hip joint. *Methods:* 6 consecutive patients affected by hip osteoarthritis were treated by intra-articular injection of autologous adipose-derived MSC between June 2017 and June 2018. Our study included only patients with constant hip pain resistant conservative treatment and OA graded 0-2 on the Tonnis grading scale. All 6 patients were evaluated in the preoperative setting and at the 6 months post-operative mark. *Results:* The HHS showed an improvement from the pre-operative baseline mean value of 67.2±3.4 to the 84.6±6.3 post-operative value. Moreover, the WOMAC score dropped from a baseline score of 36.3±4.7 to 19.8±3.4 at 6 months' post-op follow up visit. *Conclusions:* MSC Lipogems is a fairly easy technique. No adverse effects were recorded in our experience. Preliminary results showed a positive outcome according to all the grading systems used in this study even though a longer follow up is needed to validate this technique. (www.actabiomedica.it)

Key words: hip, OA, MSC, intra-articular injections

Introduction

Osteoarthritis (OA) is one of the main causes of disability in the elderly population and, more precisely the hip is the second most affected joint right after the knee. Nowadays the lifetime risk to develop symptomatic hip OA in people who live to age 85 is assessed at 25% (1-3). Intrinsic risk factors include: age, sex and genetics while extrinsic ones mostly are due to stress. Lower limb joints are subjected to repeated stress factors during daily activities which may cause classic wear and tear damages to joints cartilage. These stress factors include the increasing body mass index, high intensity of certain exercise and heavy manual labor. All the aforementioned risks combine leading to microtraumas and structural damages (2).

Since articular cartilage do not possess a high regeneration rate, due to its avascular nature, it presents a gradual chondrocytes loss, synovial hypertrophy associated with remodelling of the subchondral bone (4-5).

The first step in the treatment process of osteoarthritis is conservative treatment, which entails a course of anti-inflammatory such as NSAIDs and physical therapy to strengthen the muscles surrounding the affected joint and grant better support. In case of failure, intra articular hip joint corticosteroids or hialuronic acid injections are possible, but they have been proved just to slow down the progression.

Operative treatments such as chondroplasty or micro fracturing are ineffective, hip arthroplasty can be premature in early onset cases of OA and it is used as last resort (6).

In the last few years a new technique with Mesenchimal Stem Cells (MSC), harvested from abdominal adipose tissue, has been developed to halt the progression of osteoarthritis.

During the aging process the chondrocytes, that contribute to 5% of the volume of the articular cartilage, decrease their regenerative response, therefore a diminished production of proteoglycans and type II collagen leads to a progressive loss of the articular surface (7). While the adipose tissue has an innate anti-inflammatory quality, the MSCs are multipotent cells and still have the possibility to differentiate into chondrocytes with the adequate stimuli. MSC detect microenvironment changes through multiple growth factors and cytokines present where they reside. In addition up to 2% of cells sited in the adipose tissue are MSC compared to a 0.02% in the bone marrow (7-10). The use of Lipogems has already been proven successful in knee with mild and moderate OA thanks to its feasibility and minimal adipose tissue manipulation, thus maintaining intact the MSC. First and foremost decreased pain was reported in multiple studies associated with improved clinical and functional scores at mid-term follow up. Secondly no treatment-related adverse effects were reported (11-12). In 2017, Mcintyre et al. have published a review of 28 articles for a total of 584 patients and they concluded that intra-articular MSCs therapy is safe, with generally positive clinical outcomes (12). This retrospective study would like to demonstrate the practicality and appropriateness of hip injections with adipose tissue and MSC.

Materials and methods

Between June 2017 and June 2018, 6 consecutive patients affected by hip osteoarthritis were treated with intra-articular injection of autologous adipose-derived mesenchymal stem cells. All the operations were performed by the same surgeon (CDO). Inclusion criteria were: constant hip pain resistant to NSAIDS in the last 6 months or more, functional limitation and/or failure of the conservative treatments. Patients with a recent trauma to the symptomatic hip and with high-grade osteoarthritis (>2 of Tonnis grading system) were excluded from the analysis.

Before the treatment all patients underwent clinical examination with standard X-rays. Moreover, pre- and post-operative Harris Hip score (HHS), WOMAC and Visual Analogue Scale (VAS) pain questionnaires were collected.

Patients were placed in supine position on a standard fracture table with traction applied to the lower limbs. The abdominal wall was chosen as donor site for adipose tissue harvesting. The subcutaneous tissue of the abdominal wall was infiltrated with Klein

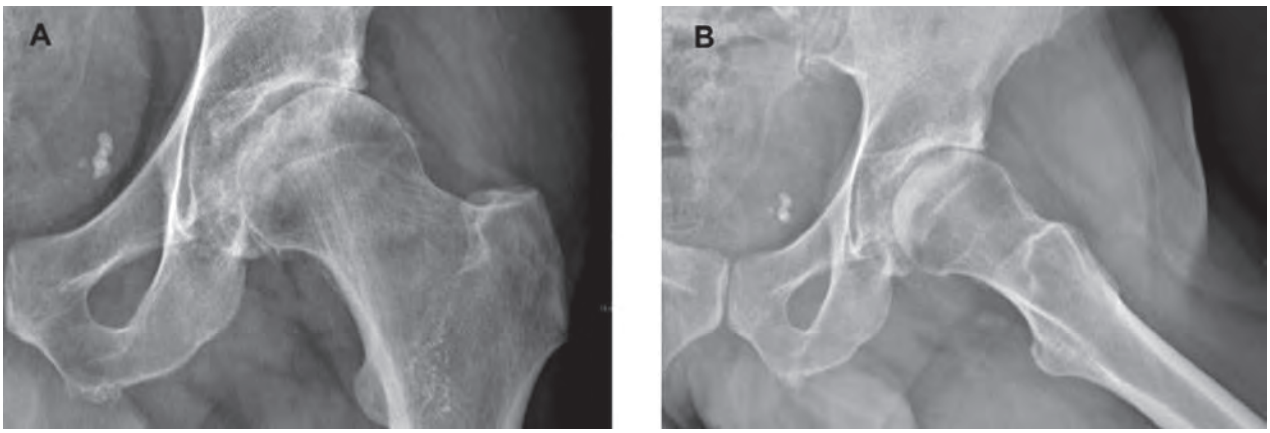

Figure 1. Preoperative Antero-Posterior (A) and frog leg (B) Xray of a left hip. This image presents a Grade 1 hip OA according to the Tonnis grading system. The joint space is slightly narrowed and the sphericity of the head maintained

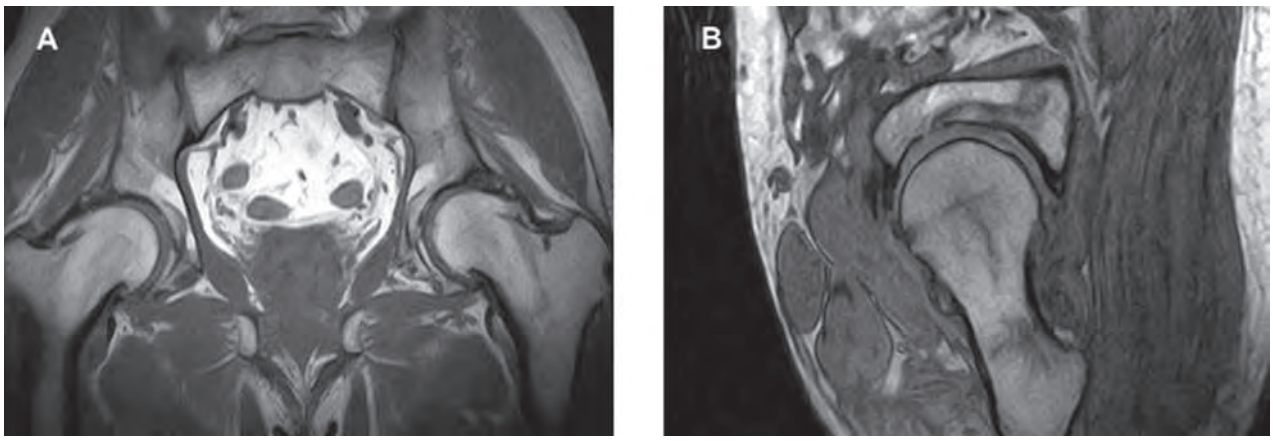

Figure 2. Pre-operative hip MRI of a 56 years old patient. A) coronal view of the hips. B) Sagittal view of the left hip

solution (10 mL of 2% lidocaine and 1 vial of 1 mg/mL adrenaline in 250 mL of saline solution) in order to prepare the harvesting site. Seven to ten minutes at least were awaited before successive adipose tissue aspiration. About 60cc of harvested fat were obtained through a normal lipoaspiration procedure and this material is immediately introduced into the Lipogems® ortho kit (Lipogems International SpA, Milan, Italy) according to the manufacturer's instructions as described by a recent study (11). By mechanical action the clusters of adipose tissue were reduced in size and the oily substances and the blood residues with inflammatory properties eliminated. At the end of the processing period about 5-10 mL of the final microfragmented adipose tissue product was injected intra-articularly under fluoroscopic control and with traction on the affected limb. All the procedures here described were performed in the same surgical stage.

The patients were discharged at home on the first post-operative day with indication of non weightbearing for 7-10 days with low molecular weight heparin until the resumption of normal walking. At the same time flexion and extension of the hip were granted immediately, indication to perform at least a post-operative physical therapy cycle, associated with painkillers as needed and local ice (20 minutes, four times a day). Moreover, indication to wear an abdominal compression binder for 20 days. Suture was removed 15 days post-op.

Pre- and 6 months post-operative data about HHS, WOMAC and VAS score were collected. The HHS has a maximum of 100 points, as follows: pain (44 points), function (47 points), range of motion (5 points), and deformity (4 points). HHS total score of <70 is considered poor, 70-80 is fair, 80-90 is good and >90 is excellent.

We have reported data as mean ± standard deviation (SD). Statistical analysis was performed with Student t test. An alpha value of $p<0.05$ was regarded as statistically significant.

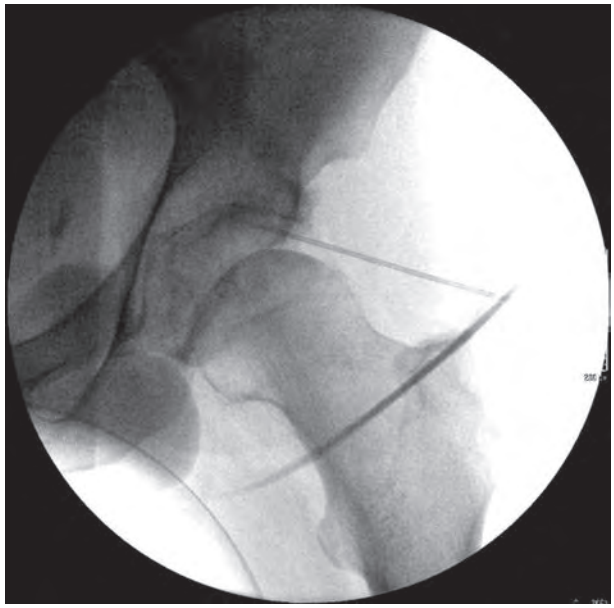

Figure 3. Intraoperative image of a left hip. During the operative time the affected limb is placed under traction to increase the joint space for the injection. Here it is possible to see a needle placed in the hip joint right before the MSC injection

Results

The mean age was 52 years (range, 37 to 60 years). There were 5 male patients and 1 female patient. All of the patients cooperated with the aforementioned post-operative instructions and rehabilitation guidelines.

The mean pre-operative HHS was 67.2±3.4 (<70 poor in five patients and 70-79 fair in one) and the mean 6 months post-operative HHS was 84.6±6.3 (70-79 fair in two patients, 80-89 good in three and >90 excellent in one) (p 0.0001). The mean total WOMAC score was 19.8±3.4 at the 6 months mark after treatment compared to the baseline score of 36.3±4.7 (p 0.0001). The mean pre-operative VAS score was 4.6±0.8 and the mean VAS score 6 months post-operative was 1.5±0.5 (p 0.0001). No patients worsened compared to their respective pre-operative condition. There was improvement of mean VAS score from pre-operative 7.6 to post-operative 3.

No patients had post-operative major complications, only one case reported an organized hematoma on the abdomen after the harvesting of the adipose tissue.

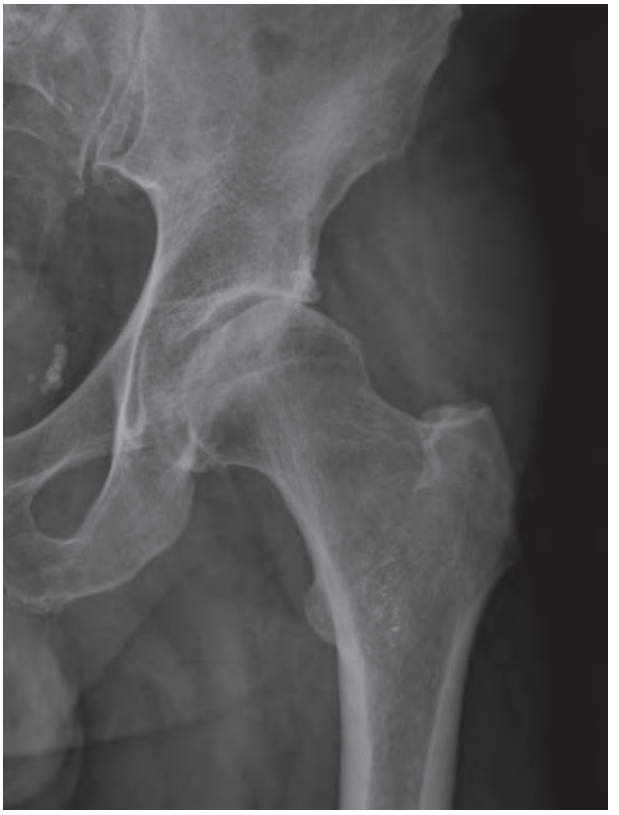

Figure 5. Left hip preoperative Xray of a 61 years old patient. Antero-Posterior view showing narrowing of the joint line. Grade 2 according to the Tonnis grading system.

Discussion

Hip OA is a chronic, progressive and debilitating disease. The goal of OA treatment is to reduce pain and increase range of motion in addition to improving quality of life for patients (13).

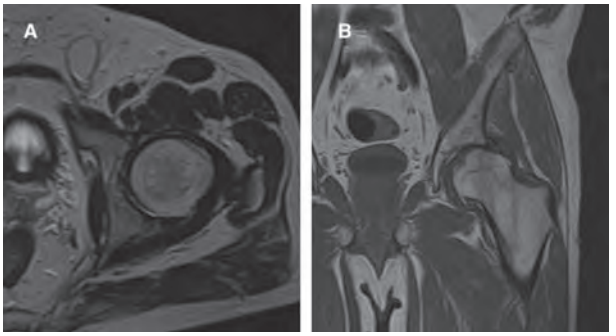

Figure 4. Preoperative MRI of a 61 years old male patient. A) Axial sequence of the left hip. Mild osteoarthritis is noticeable. B) Coronal view of the left hip. Narrowed joint space is visible, associated with sclerosis and multiple osteophytes

The main finding of this retrospective study is that injection of autologous and micro-fragmented adipose tissue is a safe treatment for early phases of hip osteoarthritis with good clinical outcome (HHS and VAS scale). It is considered a safe procedure because there were no treatment-related adverse events.

Articular cartilage lesions and degenerations, generally associated with disability and symptoms such as joint pain and reduced function, are hard to treat and remain challenging. Current pharmacologic interventions only temporarily reduce pain and symptoms, but no proven disease-modifying therapy is available (8).

The intra-articular injection of the lipoaspirate grants three main advantages: a natural anti-inflammatory, an early mechanical effect due to its large lubricating capacity and a secondary biological effect due to the ability of MSCs to secrete a variety of bioactive molecules that act in a paracrine way to prime and sustain angiogenic, antifibrotic, antiapoptotic and immu-

nomodulatory responses in target tissue (15). In a joint affected by OA the equilibrium between anabolism and catabolism is weighted in favor of degradation in OA cartilage. The potential for MSCs to restore balance in the affected joint can prevent further destruction (16-17). In our experience, we supposed a possible cross talk between the MSC and the patient's own pulvinar, in the role of mediation of the inflammation factor and the activation of the mesenchymal stem cells.

The volume of the hip joint cavity is smaller than that of the knee, so less material must be injected (5-10 mL of processed lipoaspirate) to avoid an initial discomfort of the patient.

In 2017, Pak et al. reported a case of percutaneous injections of autologous adipose-derived MSCs mixture in a patient affected by hip OA with significant relief from earlier symptoms. All clinical criteria of FRI, VAS score, and ROM improved on the patient, along with significant MRI changes (18).

In literature, there are numerous studies about treatment of knee OA with an arthroscopic procedure associated with intra-articular injection of autologous and micro-fragmented adipose tissue; in these studies arthroscopic exploration with lavage might be a potential confounding factor. In the present work, we made only the intra-articular injection without any arthroscopic procedure. Therefore, all the improvement in clinical outcome is to be ascribed to the action of the MSCs.

Limitations of the study are: the small number of participants, and no control was included and secondly, while OA has been known as a whole joint disease, the intra-articular injection of adipose-derived MSCs seemed to treat cartilage loss mainly without affecting alignment and other structures.

Conclusions

The hip injection of adipose-derived MSCs increased significantly the clinical scores in patients with early hip OA. The procedure is simple, economic, quick, minimally invasive, single-staged and there were no treatment-related adverse events in regard to the hip procedure. Despite the small number of patients, these preliminary results are positive and promising. The ultimate proof of the clinical utility of this therapy can only come, however, from a prospective, randomized therapeutic trial.

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Original article

Perioperative intravenous tranexamic acid reduces blood transfusion in primary cementless total hip arthroplasty

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Summary. *Background and aim of the work:* Blood loss and transfusion requirements are common in total hip arthroplasty. Tranexamic acid is one of the most interesting options to reduce the need for blood transfusions in a variety of surgical settings. The aim of this study was to assess the efficacy of perioperative intravenous traxexamic acid regarding blood transfusion rate and volume of transfused blood without increasing adverse events after primary elective cementless total hip arthroplasty. *Methods:* A comparative retrospective study was conducted in 86 healthy patients who had undergone primary cementless total hip artrhoplasty for severe joint diseases at a single institution. All surgical procedures were performed through an anterolateral Watson-Jones approach with the patient in supine position. Forty patients (TXA group) received tranexamic acid 1g as an intravenous bolus 10 minutes before skin incision and a further 1 g, diluted in 250 mL of saline solution, in continuous perfusion at 30 mL/h, following commencement of the surgery. Forty-six patients (control group) did not receive TXA. Outcome measures included BT rate, volume of transfused blood, deep vein thrombosis and occurrence of pulmonary embolism. *Results:* BT rate was significantly less for the TXA group (37.5%) compared with the control group (65%; p=0.011). The mean blood volume transfused was also significantly less for the TXA group (240 mL) compared with the control group (450mL; p=0.009). No adverse events occurred in any group. *Conclusions:* Perioperative intravenous tranexamic acid is effective in reducing blood transfusion rate and volume of transfused blood, without increasing the risk of thromboembolic events in patients undergoing primary cementless total hip arthroplasty. (www.actabiomedica.it)

Key words: tranexamic acid, intravenous, total hip arthroplasty, blood transfusion, blood loss

Introduction

Total hip arthroplasty (THA) is a widely used surgical procedure to treat painful and disabling hip diseases (1). THA can result in substantial amounts of intra and postoperative blood loss, which often entails a need for blood transfusion (BT) (2,3). BTs are associated with several possible complications and constitute a remarkable economic burden on healthcare systems(4,5).

The "patient blood management" advocates a conservative and limited use of blood products, aimed at preventing the need for BTs and improving patient outcome (5). A variety of perioperative blood conservation strategies have been developed to minimize blood loss and avoid postoperative allogeneic BTs, including autologous BT, patient positioning, controlled hypotensive anesthesia, intraoperative blood salvage and reinfusion drains (6,7). Furthermore, over the last few years, pharmacologic tools such as fibrin, erythropoietin, iron supplementation and tranexamic acid (TXA) have become popular (8).

Surgical trauma leads to activation of plasminogen inducing a state of hyperfibrinolysis which increases surgical site bleeding (9). TXA, an artificial synthetic derivative of the amino acid lysine, competitively inhibits both plasminogen activation and plasmin activity thus decreasing fibrinolysis process and

clot break-down (10). Perioperative intravenous (IV) TXA administration has proved to be effective in reducing blood loss and BT requirements in a variety of settings, including THA (7,11-15).

The aim of this study was to evaluate the ability of perioperative IV TXA administration (1 g preoperative loading dose and an additional 1 g infusion over 8 hours) in reducing BT rate and volume of transfused blood without increasing adverse events when used in primary elective cementless THA.

Materials and methods

We conducted a retrospective comparative study on patients undergoing primary cementless THA for severe joint diseases between December 2012 and December 2015 using our institutional blood conservation database, to evaluate the effect of perioperative IV TXA administration. All surgical procedures were performed at a single institution by two senior surgeons (DR, AS). This database included patients prior to and after the addition of TXA to our hospital. TXA dosing regimen was based on our TXA hospital's protocol used safely in bleeding trauma patients (16).

All patients undergoing primary elective cementless THA who were identified in our blood conservation database during the study period were considered for inclusion in the study. Exclusion criteria consisted of patients having history of cardiovascular disease, previous cerebral accident, coagulopathy, kidney and/or liver disease, thromboembolism, known drug reaction to TXA and patients receiving anticoagulant therapy. A total of 25 patients were excluded basing on these criteria.

A cohort of 86 patients were included and reviewed (Table 1). Forty patients (TXA group) received IV TXA (Ugurol®, Rottapharm SpA, Milan, Italy). Forty-six patients (control group) did not receive TXA. All surgical procedures were performed through an anterolateral Watson-Jones approach with the patient in supine position under lumbar or general anesthesia (Table 2). Cementless stems and cups with ceramic-on-ceramic bearing (MicroPort Orthopedics Inc, Arlington, TN, USA) were used for all arthroplasties.

Patients in the TXA group received an intravenous bolus of 1 g of TXA 10 minutes before skin incision. A further 1 g, diluted in 250 mL of saline solution, was given in continuous perfusion at 30 mL/h, following commencement of the surgical procedure. All patients received preoperative antibiotic prophylaxis consisting of IV administration of 2 g dose of cefazolin (Cefamezin®, Pfizer srl, Latina, Italy; 1000mg/10ml) 30 minutes prior to the start of operation, followed by 1 g every 6 hours for 24 hours postoperatively. Deep vein thrombosis (DVT) prophylaxis was provided with subcutaneous enoxaparin sodium 4000 IU (Clexane®, Sanofi SpA, Milan, Italy) once daily for a minimum of 30 days, beginning on preoperative day. Active physiotherapy was instructed postoperatively in all cases.

Patients were classified by age, gender and surgical duration. The operative risk was assessed according to the American Society of Anesthesiologists (ASA) classification. Haemoglobin (Hb) levels were assessed preoperatively, at 6 hours, 24 hours, 48 hours, and 5 days postoperatively. Number of patients requiring BT, drop of Hb, volume of transfused blood and adverse effects were also recorded and compared. Patients with Hb levels <8 g/dL were considered for BT.

Outcome measures included BT rate, volume of transfused blood, deep vein thrombosis (DVT) and occurrence of pulmonary embolism (PE). DVT were screened for clinically with no investigations being performed unless there was clinical suspicion. After discharge, patients were checked up at 3 and 6 months postoperatively according to our routine follow-up.

Stata software (StataCorp LP, USA) was used for statistical analysis. Statistical differences between the TXA group and the control group were compared using χ^2 or Fisher exact test for categorical variables and Mann-Whitney U test for continuous variables, specifically. Results were expressed as the mean ± standard deviation. A value of $p<0.05$ was considered to be statistically significant.

Results

All the 86 patients were successfully reviewed (Tables 1, 2). No statistically significant differences were found between the two groups with regard to

Table 1. Patients' demographics and baseline characteristics

		TXA group	Control group	*p* value
N. of patients		40	46	NA
Gender	female/male	18/22	24/22	0.525
Age	years	65.2 ± 16.1	71.4 ± 9.1	0.215
ASA status	I/II/III/IV	4/36/0/0	3/43/0/0	0.749
Diagnosis	POA	26	30	0.983
	DDH	3	2	
	RA	3	2	
	FHN	7	12	
	AS	1	0	
Side	right/left	19/21	27/19	0.387
Operation time	minutes	115.25 ± 22.8	96.05 ± 5.9	0.000*

Legend POA: primary osteoarthritis; DDH: developmental dysplasia of the hip; RA: rheumatoid arthritis; FHN: femoral head necrosis; AS: ankylosing spondylitis; NA: not applicable; *statistically significant

Table 2. Patients' perioperative data

		TXA group	Control group	*p* value
N. of patients		40	46	NA
Type of anaesthesia	G	21	29	0.423
	L	14	12	
	G+L	5	5	
Preoperative Hb [g/dL]		13.7 ± 1.3	13.9 ± 1.3	0.332
Postoperative Hb [g/dL]				
immediate postoperative		10.6 ± 1.6	10.7 ± 1.4	0.762
48 hours		9.8 ± 1.1	9.6 ± 1	0.434
5th day		9.9 ± 0.9	9.9 ± 1	0.978
Hb difference [g/dL]				
preoperative - immediate postoperative		3 ± 1.5	3.2 ± 1.3	0.548
preoperative - 48 hour postoperative		3.8 ± 1.3	4.3 ± 1.3	0.111
preoperative - 5th day postoperative		3.7 ± 1.4	4 ± 1.5	0.374
N. of patients transfused		15	30	
BT rate (%)		37.5	65	0.011*
Volume of transfused blood [mL]		240 (0-1200)	450 (0-1500)	0.009*

Legend G: general; L: lumbar; NA: not applicable**;** *statistically significant

preoperative parameters (age, gender, side, ASA status, diagnosis, Hb level).

The mean operation time was 115.25±22.8 minutes for the TXA group and 96.05±5.9 minutes for the control group (p=0.000). The mean preoperative Hb level was 13.7±1.3 g/dL in the TXA group and 13.9±1.3 g/dL in the control group (p=0.332). The mean immediate postoperative Hb level was similar in both TXA and control groups, 10.6±1.6 g/dL vs 10.7±1.4 g/dL, respectively (p=0.762). The mean 48-hour postoperative Hb level was higher in the TXA group, 9.8±1.1 g/dL vs 9.6±1 g/dL (p=0.434). Mean 5th-day postoperative Hb reached similar values: 9.9±0.9 g/dL in TXA group vs 9.9±1 g/dL in the control group (p=0.978). The highest difference between mean pre- and postoperative variation of Hb was measured 48 hours after surgery, 3.8±1.3 g/dL in the TXA group and 4.3±1.3 g/dL in the control group, although it was not statistically significant (p=0.111). Compared with control group, patients who received TXA had a significant reduction in BT rates (65% vs 37.5%, p=0.011) and lower mean blood volume transfused (450 mL vs 240 mL, p=0.009). No TXA allergy and thromboembolic complications occurred in any group.

Discussion

THA is associated with major blood loss and frequently requires BTs for postoperative anemia, and BT rates varies between 21% and 80% (2,3,17). In OSTEO study, Rosencher et al. (17) investigated a total of 2640 hip arthroplasty patients quantifying perioperative blood loss at mean 1934 mL total blood. Allogeneic BTs have several risks like transfusion-related reactions, infections, and immunomodulatory effects (18). Additional health cost is also a rising concern (5).

Several blood conservation techniques have been employed to reduce blood loss and the exposure to BTs (6,7). A possible pharmacological option to prevent surgical bleeding in hip replacement surgery is the use of TXA (13,15). TXA, originally discovered in 1962 by Utako Okamoto (19), exerts its antifibrinolytic effect by a reversible interaction with plasminogen and the active protease, plasmin, inhibiting the activation of the plasminogen and retarding the fibrinolysis cascade process (10).

IV delivery is the most common route for TXA administration in published studies regarding total joint arthroplasties (20). Andersson et al. (21) showed that in healthy patients receiving a single bolus of TXA (10 mg/kg dose) the highest plasma concentration was measured within 1 hour, with 30% excreted in the urine after 1 hour, 55% at 3 hours, and 90% after 24 hours. The half-life of IV TXA is 2 hours (22). Furthermore, TXA diffuses rapidly in the joint fluid and synovial membrane, reaching the same concentration in the synovial fluid as in the serum 15 minutes after IV administration (23).

We found that BT rates and mean volume of transfused blood were less in the TXA group compared to the control group: 37.5% vs 65% (p=0.011) and 240 mL vs 450 mL (p=0.009), respectively, although the median surgical time was statistically significantly longer for the TXA group. These results were consistent with previous studies (13,20). In a systematic review and meta-analysis, Sukeik et al. (13) investigated the efficacy of IV TXA vs placebo in reducing blood loss and BT in THA, and showed that preoperative IV TXA reduced intraoperative blood loss by a mean of 104 mL, postoperative blood loss by a mean of 172 mL, and total blood loss by a mean of 289 mL, leading to a 20% reduction in the proportion of patients who required BTs. Moskal et al. (20) focused on IV TXA administration vs placebo in primary THA, analyzing only data of randomized controlled studies. IV TXA was more beneficial than placebo for blood loss intraoperatively, blood loss through drains, and total blood loss during hospitalization, in addition to reducing allogeneic BT rates (8.20% vs 19.52%).

Clinical studies investigating the effect of intravenous TXA in THA are heterogeneous regarding dosage schedules and timing of administration. The contrasting results highlight the importance of the appropriate timing of administration. In a randomized double-blind trial, Benoni et al. (24) reported that IV use of TXA at the end of the operation and 3 hours later did not reduce postoperative blood loss, demonstrating inadequate timing of TXA administration. On the other hand, a similar placebo-controlled study conducted by Ekback et al. (25) demonstrated that IV TXA prior to

the start of the surgical procedure showed significant benefit for both intra- and postoperative blood loss in the TXA group. Yamasaky et al. (26) and Rayesparan et al. (27) reported that a 1 g IV TXA, given at the induction of anaesthesia, reduced postoperative blood loss but did not reduce intraoperative blood loss. Firstly, Imai et al. (7) evaluated the effects of TXA examining the timing of its administration during THA. One hundred seven patients were randomly divided into 5 groups: no TXA administration (control group), single administration (either preoperative or postoperative phase), and double administration (preoperative or postoperative and 6 hours after first administration). They found that the intraoperative blood loss in the preoperative TXA administration groups was significantly lower than both control and postoperative groups. They concluded that two administrations of TXA, 1 g given 10 minutes before surgery and 6 hours later, significantly reduced blood loss without increasing the risk of thromboembolic events. Similarly, in our study, patients received TXA as a loading intravenous bolus dose of 1 g over 10 minutes prior to skin incision, followed by an additional 1 g, diluted in 250 ml of saline solution, given in continuous perfusion at 30 mL/hour. The rationale for this protocol is that the preoperative TXA bolus should help the surgeons to take advantage of the 120 minutes of TXA plasmatic half-life. Moreover, the continuous 8-hour TXA supplementary infusion should be able to maintain the therapeutic plasma concentration of TXA and stabilize the postoperative hematoma, further preventing the postoperative blood loss.

In the present study, immediate postoperative Hb levels were similar in both groups, as previously reported by other authors (26,27). The highest variation of pre- and postoperative Hb difference between the TXA group and the control group, although not statistically significant, was observed at 48 hours after surgery (3,84 g/dL vs 4,29 g/dL, p= 0,111). The postoperative hematoma is likely to become unstable after 48 hours because of the cessation of the TXA effect. This could explain the frequent need of BTs on the second or third day following surgery. Hb level decrease did not significantly differ between the two groups 5 days postoperatively, as the beneficial effect of TXA in preventing blood loss could be counterbalanced by the larger amount of transfusions to the control group.

TXA is contraindicated in patients with history of hypersensitivity and allergy to TXA, previous venous or arterial thrombosis, risk for thrombosis or thromboembolism, heart disease, hepatic dysfunction, and acute renal failure(7,28). The major concern of using TXA is an increased risk of thromboembolic events. The current investigation and most previous studies have excluded patients with significant risk factors, such as a history of cardiovascular disease, thromboembolic events, and renal failure. According to our findings and literature data, IV TXA administration in healthy patients undergoing THA did not appear to increase the incidence of thomboembolic events compared with the placebo groups (13,20,29). However, studies of TXA in THA have failed to adequately evaluate its effects on the risk of DVT, because in most of them the patients had only a clinical evaluation, and this should to be the subject of future research.

The limitations of the current study include the retrospective review of the data and the small sample sizes. Moreover, the total intraoperative bleeding was not measured, and the diagnosis of DVT or PE was based only on clinical evaluation. However, the two groups of patients were well matched for age, sex, diagnosis, and comorbidities. Furthermore, all patients were operated on by the same surgeons using the same surgical approach and standard cementless THA, thus excluding possible surgical factors affecting blood loss.

Conclusions

BTs requirements in THA can be reduced with various blood conservation techniques. TXA is one of the most interesting options to decrease the need for BTs. The current study found that perioperative IV administration of TXA in patients undergoing primary elective cementless THA resulted in reduction of BT rate and volume of transfused blood, without increasing the risk of thromboembolic events. Prospective randomized trials with larger patient populations are required to confirm our preliminary findings, define the optimal drug regimen, and verify the safety and cost-effectiveness of TXA in THA.

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Original article

Higher blood loss and transfusion requirement in surface arthroplasty versus conventional total hip replacement

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Summary. *Background and aim of the work:* Surface replacement arthroplasty (SRA) is an alternative to stemmed total hip arthroplasty (THA) providing a femoral bone preserving procedure. Because of the wider surgical dissection, an increased blood loss could be expected. This retrospective study evaluates the transfusion requirement in two homogeneous groups of patients who underwent primary hip replacement electively. *Methods:* Perioperative haematological data of 42 hip resurfacing procedures and 41 conventional cementless THAs were compared. The pre- and post-operative haemoglobin (Hb) levels and the amount of blood transfusions were registered. The median values were compared with use of the non-parametric Wilcoxon signed-rank test. *Results:* In the SRA group, a significantly increased ($p<0.02$) preoperative Hb concentration (13.1 g/dL, range 10.9 to 15.6) was detected in comparison with the THA group (12.5 g/dL, range 10.4 to 15.2). In the resurfacing procedures a median of 900 mL (range 600 to 1500) were transfused vs. 600 (range 300 to 1500) in the conventional THAs, demonstrating a significantly higher transfusion requirement ($p<0.04$). *Conclusions:* Whereas hip resurfacing is a femoral bone preserving alternative to conventional THA with comparable clinical and radiographic outcomes, higher blood loss and transfusion requirement may occur. (www.actabiomedica.it)

Key words: blood loss, Hb level, hip resurfacing, total hip arthroplasty, transfusion requirement

Introduction

Elective total hip arthroplasty (THA) is well established as an effective treatment for symptomatic osteoarthritis of the hip (1), although it is commonly associated with blood transfusions intra- and post-operatively (2).

Surface replacement arthroplasty (SRA) is a relatively new procedure of hip replacement that includes a high potential both for joint biomechanical restoration and femoral bone preservation (3-6). In a SRA, only the articular surfaces of the femoral head are removed, and the neck is left in situ. Consequently, the access to the acetabulum is severely reduced and a wider surgical dissection is required.

Therefore, higher blood requirements could be expected, but only a few published reports have directly compared the two procedures. In two different studies, hip resurfacing had an increased median blood loss, although not significant (7, 8), whereas Fowble et al. found less total blood loss ($p=0.0005$) and fewer transfusions ($p<0.0001$) following SRA (9). Similarly, in a recent meta-analysis review, a greater requirement for blood transfusion was detected in conventional THAs (10).

This retrospective study compares the incidence of blood loss and transfusion requirement in two groups

of patients who received either surface or stemmed total hip arthroplasty.

Materials and methods

This retrospective study enrolled all patients who received elective hip prosthesis in the period August 2004 until June 2009. Forty-two hybrid metal-on-metal resurfacing procedures were performed on 39 patients, 27 males and 12 females (3 having bilateral involvement), with age ranging from 27 to 72 years (median 60). This population was compared with a series of 41 conventional cementless THAs with ceramic-on-ceramic bearings which were performed in 21 males and 18 females (2 were operated on bilaterally), aged from 30 to 77 years (median 67).

The operations were predominantly for primary osteoarthritis (28 and 24 hips, respectively) in patients who had failed nonoperative treatment. Other etiologies were avascular necrosis of the femoral head (7 and 8 cases), posttraumatic arthritis (3 and 1), hip dysplasia (3 in both groups), slipped capital femoral epiphysis (1 resurfacing), and rheumatoid arthritis and ankylosing spondylitis (4 and 1 conventional THAs). Indications for hip resurfacing were considered young age and high activity level. Therefore, the patients were predominantly males (66.7%), with a median of seven years younger than patients receiving THA (60 vs. 67 years, respectively; $p<0.002$). However, the gender difference was not significant ($p<0.23$). No patient in both groups had undergone previous hip surgery. All procedures were performed by the same surgical team via an anterolateral Watson-Jones approach with the patient in supine position (Table 1). No patients in both groups received tranexamic acid by means of topical or intravenous administration.

The haemoglobin (Hb) concentration was measured the day before and after surgery and immediately before discharge (4 or 5 days postoperatively) in order to evaluate blood loss. The total amount of blood transfusion was recorded for all patients as well. Postoperative transfusions were considered for both cohorts when Hb level was <9 g/dL.

Haematological parameters, age, and BMI were expressed as minimum, maximum, and median values, and compared by use of the Mann-Whitney U test, as variables were quantitative and non-normally distributed between groups (11). These data were performed using Stata IC version 10.1 software (StataCorp, 2007) (12). The difference of ratios (overall number of patients, gender, diagnosis, affected side, and number of

Table 1. Demographic data of patients undergone to surface replacement arthroplasty (SRA) and conventional total hip arthroplasty (THA)

		SRA	THA	p (*/#)
N hips (N patients)		42 (39)	41 (39)	
Sex	Female	12 (2 bilateral)	18 (2 bilateral)	0.15*
	Male	27 (1 bilateral)	21	
Age (years)		60 (27-72)	67 (30-77)	**0.002#**
Body mass index		26 (20-32)	27 (17-38)	0.98#
Diagnosis	Primary arthritis	28	24	0.29*
	Head necrosis	7	8	
	Other	7	9	
Side	Right	24	21	0.59*
	Left	18	20	

*: chi-square test; #: Mann-Whitney U test

patients transfused) was evaluated using the chi-square test with Yates' correction for continuity, as non-continuous dichotomous data (13). Analysis involved the use of the R Development Core Team (2008) statistical software (14). A p value less than 0.05 was considered statistically significant.

Results

Preoperatively, the haemoglobin level was significantly higher in the resurfacing group (13.1 g/dL, range 10.9 to 15.6) compared with conventional THAs (12.5 g/dL, range 10.4 to 15.2) ($p<0.02$). However, no statistically significant difference persisted at discharge: 10.2 g/dL (range 7.6 to 12.2) and 10.1 g/dL (range 7.2 to 12.3), respectively ($p<0.72$). The number of patients who received blood transfusions following surface and conventional arthroplasty was equivalent (36 and 35, respectively). However, the median requirement of transfusions was significantly higher ($p<0.04$) in the SRA group (900 mL, range 600 to 1500) in comparison with the THA group (600 mL, range 300 to 1500) (Table 2).

Consequently, resurfacing procedures showed an increased perioperative blood loss compared with stemmed THAs.

Discussion

Although associated with significant blood loss (2), total hip arthroplasty is a widely used surgical technique for the treatment of severe diseases of the hip joint (1). Due to the limited resection of the femoral bone, hip resurfacing has been developed as an effective alternative in young and active patients (15, 16). Comparable clinical and radiographic results of surface and conventional prostheses have been recently reported (9, 17-19). Hip resurfacing requires a more extensive surgical exposure compared with conventional THA, and an increased blood loss could occur. At present, only a few studies have provided data on blood management derived from comparisons of standard hip arthroplasty and resurfacing procedure, and the results are controversial.

Vail et al. retrospectively compared the outcomes of 52 patients (57 hips) who underwent surface arthroplasty with 84 patients (93 hips) who received conventional primary THAs during the same time period (7). The patients had a mean age of 47 years (range 22 to 64) and 57 years (range 17 to 92), respectively. Estimated blood loss was 418 mL and 412 mL, respectively. In a randomised prospective study by Vendittoli et al., the early clinical results of 103 SRAs and 102 cementless THAs were assessed (8). The mean volume of blood loss was 524 mL (range 100 to 2200) in SRA and 482 mL (range 100 to 3300) in THA. The mean transfusion rate was 4.7% and 9.7%, respectively, but no significant difference between the two groups was detected. In a small comparison study of 50 consecutive metal-on-metal surface replacements and 44 consecutive conventional total hip arthroplasties, hip resurfacing had less estimated intraoperative blood loss ($p=0.005$) and less postoperative drain output ($p=0.05$), resulting in 252 mL (719 mL for SRA, 971 mL for THA) less total blood loss ($p=0.0005$) and fewer blood transfusions: 12/50 (24%) for SRAs,

Table 2. Haemoglobin levels (Hb) and transfusion requirement in patients who received surface replacement arthroplasty (SRA) and conventional total hip arthroplasty (THA)

	SRA	THA	p (*/#)
Preoperative Hb [g/dL]	13.1 (10.9-15.6)	12.5 (10.4-15.2)	**0.02#**
Postoperative Hb [g/dL]	10.2 (7.6-12.2)	10.1 (7.2-12.3)	0.72#
Hb difference (pre-post) [g/dL]	3.0 (0.6-5.5)	2.5 (0.1-5.5)	**0.04#**
N patients transfused	36/42	35/41	0.96*
Blood transfusion [mL]	900 (600-1500)	600 (300-1500)	**0.04#**

*: chi-square test; #: Mann-Whitney U test

28/44 (64%) for THAs (p<0.0001) (9). In 2010, Smith et al. evaluated the clinical and radiological outcomes of resurfacing procedures compared with stemmed arthroplasties reviewing 46 studies (3799 SRAs and 3282 THAs) (10). Although THA was associated with a greater transfusion requirement (RR=0.4, CI 0.2-0.6, p<0.001), the related greater estimated blood loss (MD=-152.8, CI -305/-0.5, p<0.05) has to be regarded with caution, due to the high levels of statistical heterogeneity reported.

As little and inadequate data were available, we were encouraged to perform the present study. In our experience, the greater median requirement of transfusions after hip resurfacing (600 vs. 900 mL; p<0.04), despite higher preoperative levels of haemoglobin (13.1 vs. 12.5 g/dL; p<0.02) documents the larger amount of blood loss associated with SRA.

In the last decade, many different strategies regarding transfusion practice have been developed to reduce postoperative requirement of blood transfusions (less invasive surgical procedures, use of procoagulant drugs and topical haemostatic agents, perioperative blood salvage).

Moreover, the validity and effectiveness of a restrictive transfusion policy have been definitively demonstrated in a variety of clinical settings, and THA actually requires less red blood cell transfusions (20).

The weaknesses of this study include the non-randomized design and the limited patient population. However, the demographics were comparable, as the two groups were homogenous for all but age at operation, which conditioned the choice of the surgical procedure. Finally, the most relevant strength of the study is the occurrence that all operations were performed by the same surgical team using the same anterolateral approach.

In conclusion, recent tribological improvements make surface replacement arthroplasty a successful alternative to conventional THA in patients with end stage hip damage, with comparable long-term outcomes. However, the preservation of proximal femoral bone requires longer operative times and wider surgical exposures, and the need of increased blood transfusions has to be considered.

Further studies including larger patient populations are needed to definitively confirm these findings.

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ORIGINAL ARTICLE

Heterotopic Ossification in Primary Total Hip Arthroplasty: which is the role of drainage?

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Summary. *Background and aim of the work:* The Heterotopic Ossification (HO) is a common complication following Total Hip Arthroplasty (THA). Although there is no concordance in Literature regarding the etiopathogenic mechanism, various HO risk factors have been recognized, both related to the patient and associated with the surgical procedureLiterature does not consider the use of intra-articular drainage as a possible risk factor. Our hypothesis is that this item can contribute to the development of HO. *Materials and Methods:* 425 implants of hip arthroplasty performed between 2014 and 2017 at the Ortopedic Clinic of Udine were included in the study. No patient performed pre-operative or post-operative anti-HO prophylaxis during follow-up. Radiographs of preoperative and postoperative at 1 year were analyzed according to the Brooker Classification. *Results:* The incidence of HO in patients with intra-articular drainage is 24.6%, while the incidence of HO in patients without intra-articular drainage is 15.3%, with a statistically significant difference. *Conclusions:* The data obtained suggest to consider the use of intra-articular drainage as a possible intra-operative risk factor for HO. This is a retrospective cohort study, so we need more studies and more robust experimental designs to confirm these results. (www.actabiomedica.it)

Key words: Heterotopic Ossification, Total Hip Arthroplasty, drainage

Introduction

The Heterotopic Ossification (HO) is defined as the formation of mature and lamellar bone infiltrated at the soft tissue level, then out of the physiological skeletal structure (1, 2). These HO represent a common complication for orthopedic and traumatological surgery, but in particular it is frequently associated with hip prosthetics. The most probable incidence of HO varies from 28% to 61% (3-10). Generally HO is asymptomatic. In a small percentage of cases local pain and limitation of joint excursion may occur (11, 12). The most used classification to describe is the Classification of Brooker (13). The etiology and pathogenesis of HO have not yet been established with certainty. Literature recognizes risk factors related to the patient (male, age, obesity, arthrosis, etc.) and to the surgical procedure (surgical access, type of anesthesia, intraoperative blood loss, duration of the procedure, etc.). In any case, it has not yet been established with precision if and which risk factors may have a greater influence on the location and quantity of HO (14,15). The use of intra-articular drainage is an element not considered in literature as a risk factor. Our study consider the presence or absence of drainage in a heterogeneous group of hip arthroplasty implants, to detect any difference in the incidence of HO.

Materials and Methods

The present study regards all the arthroplasty hip implants performed at the Ortopedic Clinic of Udine from 1st of January 2014 to 31th of December 2017.

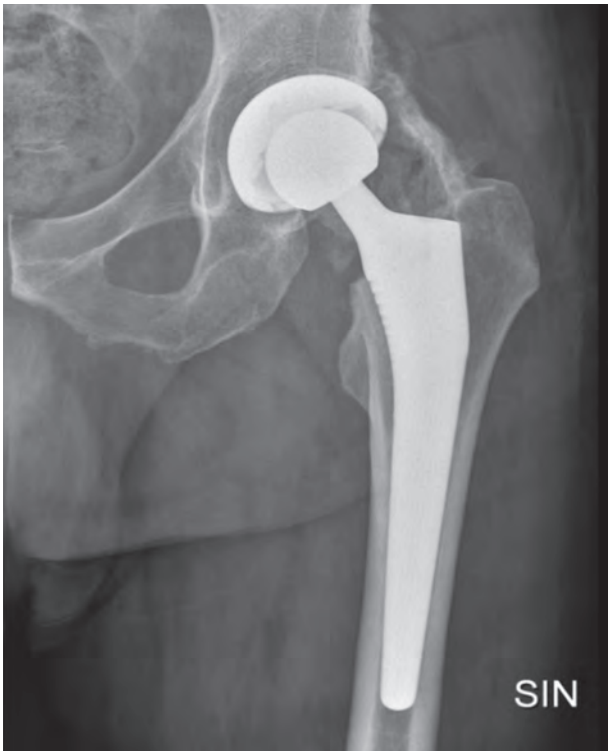

Figure 1. One year post-operative xray showing HO Class IV Brooker's

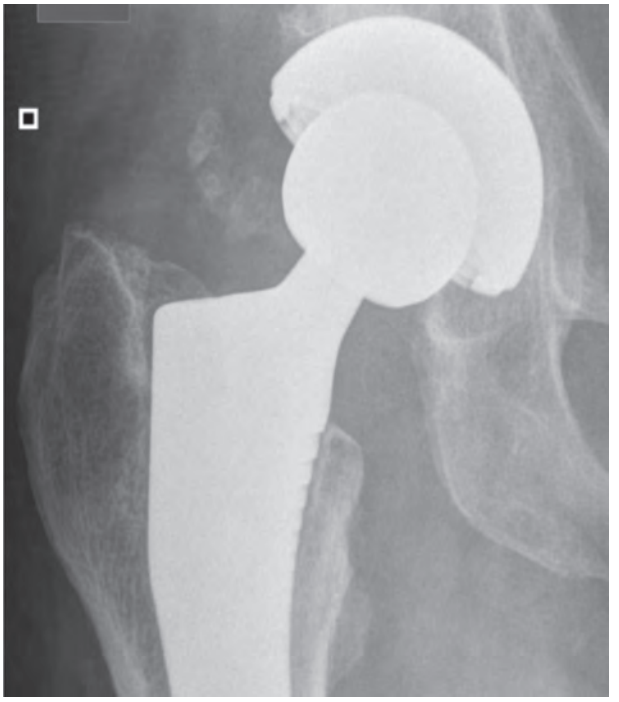

Figure 2. One year post-operative xray showing HO Class I Brooker's

Surgical operations were performed by five surgeons of the Orthopedic Clinic, all with high rate of experience for this type of surgery. Patients diagnosed with infection, patients who performed prophylactic therapy for HO and patients undergoing prolonged immobilization, were excluded from the study. The proposed diagnoses included primary coxarthrosis, aseptic necrosis of the femoral head, outcomes of congenital hip dysplasia, outcomes of trauma and fracture of the coxo-femoral joint. All THA were followed up to 1 year post-intervention with a frequency of 45 days, 3 months, 6 months and a year. At each clinical control, in addition to the clinical examination, an X-ray of the pelvis in AP and 2 projection (AP and LL) of the operated hip were examined and archivied. With a follow-up of at least one year it was therefore possible to recognize the presence and evolution of any HO. The HO were classified according to the Brooker Classification.

For each patient were considered age, gender, admission diagnosis, the surgical procedure performed, the type of implant used and the presence or absence of intra-articular drainage (drainage is always removed in the first day post-operative). The probable higher incidence of HO in patients with drainage was then calculated.

Results

The total number of THA performed is 425. Of these 408 by Direct Anterior Approach (DAA) and the remaining 17 by Direct Lateral or Anterior-Lateral Approach. Of the total 425 hip arthroplasty at 1 year, 90 patients had radiological evidence of HO (21.2%) (Table 1).

In details, following the Classification of Brooker, 33 Class I, 32 Class II, 19 Class III, 6 Class IV. Of the 90 patients in the group with HO, 62 were male (68.9%) (Table 2).

On the 425 implanted hip arthroplasty 265 had intra-articular drainage (62.3%). Of the 90 patients in the group with HO, 66 also had intra-articular drainage (73,3%). The percentage of patients with ossification and drainage is 24.6%. The percentage of patients

with ossifications but without drainage is 15.3% (Table 3). The difference of HO incidence in the two patience groups is statistically significant (p-value 0,0229).

For only 3 patients (all Class IV) a new surgical approach was needed to remove periarticular HO with good benefits.

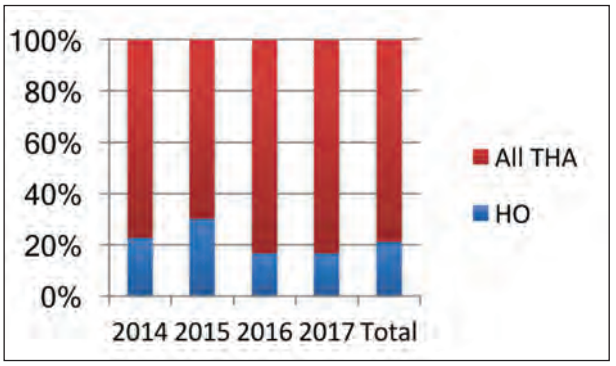

Table 1. HO rate in our study

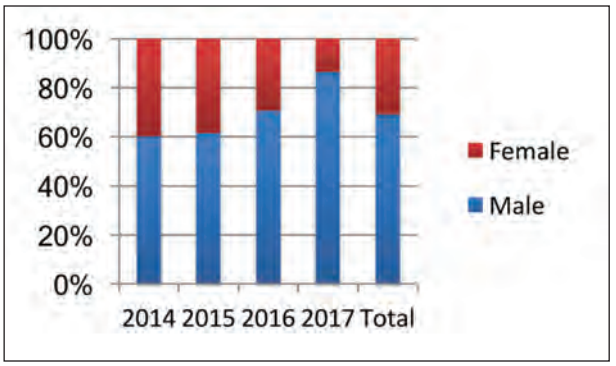

Table 2. Distribution of HO according to gender

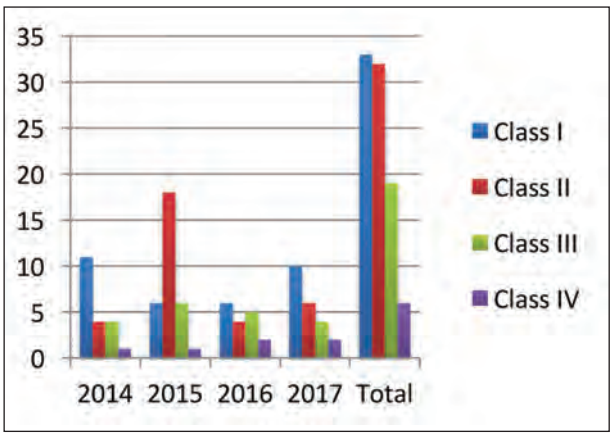

Table 3. HO according to the Brooker Classification

Discussions

Among the orthopedic surgical procedures, the hip arthroplasty is the most affected by the onset of HO. The knee is affected less by this complication. The incidence of HO post-THA varies from 28% to 61% (3-10). According to some Authors the spectrum is between 5% and 90% (16). The result is probably so uncertain and not precise because the HO is often random, and in most cases have no clinical relevance. Only in a small percentage of patients ranging from 3% to 10% a symptomatology can be manifested, which may be local erythema and swelling, pain and limitation of the ROM (17,18). The most famous and most used classification is the Brooker one; through the study of a simple radiography of the antero-posterior pelvis, four classes can be differentiated: Class I (HO islands within periprosthetic soft tissues), Class II (bone proliferations from the apex of the great trochanter or from the acetabulum with space greater than 1 cm between the two extremities), Class III (bone proliferation from the apex of the great trochanter or from the acetabulum with space less than 1 cm between the two extremities, Class IV (apparent hip bone anchor) (13).

Generally HO starts to manifest in the first 6 weeks and is mature and recognizable no later than 6 months post-intervention (11,13). Several studies have recognized the benefits of treatment with NSAIDs, Indomethacin and radiation therapy against the development of HO. These therapies can perform a beneficial action both as preoperative prophylaxis and as postoperative therapy (19-21). The etiology of this calcific phenomenon is unknown. Genetic exposure has not yet been established (22). The first description of HO dates back to 1692 performed by Patin in a child

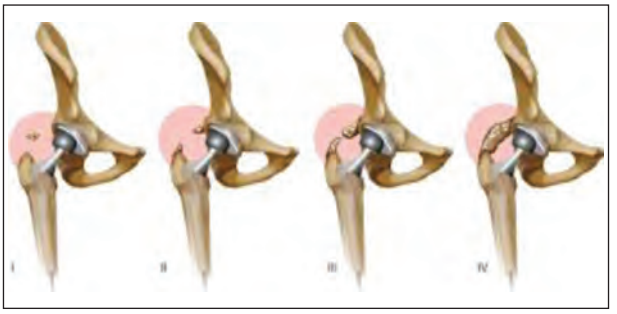

Figure 3. Brooker Stages

affected by myositis ossificans progressiva (23). Since then, several authors have proposed specific pathogenic mechanisms, but there is still no agreement. During the Great War the HO was manifested more in paraplegic soldiers with injuries to the vertebral column from explosion. This phenomenon suggests that the probable responsible for the development of HO are soft tissues, bone tissue and the nervous system. Literature therefore considers these structures to be probable guylties of HO (24-26). As for the ossifications in general, even the HO post-THA was not a shared etiology. The most accredited etiopathogenetic mechanism provides that it is the result of the release of some osteogenic factors released following the injury of the soft tissues located around the coxo-femoral articulation (27). The specific and agreed risk factors for HO are male sex, hypertrophic arthrosis, obesity, ankylosing spondylitis, rheumatoid arthritis, post-traumatic arthritis, Paget's disease and idiopathic skeletal hyperostosis. . Other risk factors, although not yet agreed in Literature, may be related to surgery, such as the type of anesthesia, the duration of the operation, the possible blood transfusion, and especially the surgical approach performed (28, 29). Several authors have tried to deepen this aspect, unfortunately with poor results. The theory according to which a lower trauma of the soft tissues decrease the HO has positively influenced the choice of the Anterior surgical approach. The Direct Anterior Approach is finding more and more space in recent years. It is also our path of choice, because it is an intermuscular and internervous pathway that has shown a lower traumatism of the peri-articular tissues, an early mobilization of the patient, an adequate ROM in shorter times and a lower index of dislocation (30-34). In any case, the Literature has not yet agreed on establishing the influence of the access pathway on the incidence of HO (36). Probably it is necessary to elaborate on and research other risk factors.

An element not so considered in Literature is the use of drainage. The level of dissection and trauma of the soft tissue during surgery can affect the incidence of HO. Elements such as bone debris, the fixation technique of prosthetic components and the development of a hematoma under the fascia, have been taken into account as further factors affecting the HO (28, 29). The most accredited etiopathogenetic mechanism predicts that these factors favor release of bone-inductive factors. Furthermore, the trauma of the surrounding soft tissues creates an environment favorable to the local proliferation of fibroblasts and the accumulation of extracellular matrix, which will evolve in HO through endochondral ossification (37-40). It has not yet been established whether the osteogenic mediators are released from stimulated bone tissue or soft tissue directly (41). Giving credit to this pathogenetic mechanism, the use of drainage is an important factor to consider. Peri-articular drainage performs the draining action preventing the accumulation of local serum-hematic fluid. In relation to the genesis of HO, the positioning of the drainage determines an additional source of trauma to the soft tissues. The presence of drainage also allows an additional way of spreading osteogenic mediators through soft tissues. Furthermore, the presence of a foreign body such as drainage can favor a locally recall of inflammatory factors that can stimulate the start of the forming process of HO.

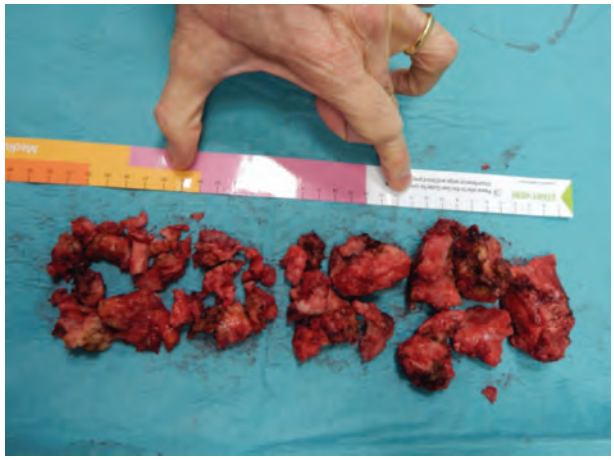

Figure 4. HO removed after surgery

Conclusions

According to the data obtained, the presence of drainage could favor the development of HO. Our study has several limitations, including the fact of being a retrospective study, the number of patients, not having considered further variables and risk factors in the selection and classification of patients. Nevertheless, the data obtained are statistically significant, so it

could be a first step to deepen the subject. In any case further studies and analyzes are necessary with more data to obtain an adequate result.

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Original article

Dual mobility total hip arthroplasty in the treatment of femoral neck fractures: a retrospective evaluation at mid-term follow-up

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Summary. *Background and aim of the work:* Partial or total hip replacement is the method of choice for displaced femoral neck fractures (FNF) treatment. Dislocation is a major complication, accounting for about 3.8% of cases for hemiarthroplasty (HA) and 10% for total hip arthroplasty (THA). Dual-mobility (DM) socket in total hip arthroplasty showed a very low rate of dislocation in both primary and revision setting THA. Some literature reports show good results with low dislocation rates also in FNF treatment at short term follow-up. Aim of the study was to evaluate clinical and radiographic results of DM-THA in FNF treatment at mid-term follow up. *Methods:* Study population counted 31 implants in 30 patients treated with DM-THA for FNF between January 2010 and December 2012. Dislocation rate was identified, and HHS and OHS were completed. Twenty-four patients underwent also radiographic evaluation to assess cup integration and sings of loosening. *Results:* No episodes of hip dislocation nor intraprosthetic dislocation were found. Other postoperative complications were recorded in 9,67%. HHS and OHS showed a mean value of 81,22 and 37,37, respectively. There were no cases of clinical and radiographic signs of implant loosening. *Conclusions:* The present study confirms the good clinical results, low complications and very low dislocation rate with DM THA for FNF treatment. (www.actabiomedica.it)

Key words: dual-mobility, femoral neck, proximal femur fracture, THA dislocation, mid-term

Background and aim of the work

Femoral neck fractures (FNF) represent a major public health problem worldwide. Hip hemiarthroplasty (HA) represents the preferred method of treatment in most cases (1), due to relative technical ease and low invasiveness of the procedure. On the other hand, total hip arthroplasty (THA) is associated with a lower rate of re-operation, less pain and a better functional outcome (2). Therefore, THA is indicated by many authors for FNF treatment especially in younger patients without severe comorbidities and with relatively high functional demand. One of the most relevant complications of arthroplasty for FNF treatment in represented by dislocation, with an incidence reported around 3.8% for HA and 10% for THA (3, 4, 5). Nonetheless, FNF patients are at high risk for prosthetic dislocation with respect to hip arthritis patients, because of a combination of muscular insufficiency, cognitive and neurologic disorders and recurrent falls that characterize this population of patients. With the introduction of the dual-mobility (DM) socket, many authors reported a lower dislocation rate both in primary THA and revision implants (6). On the other hand, DM implants can suffer a unique failure mechanism known as an intraprosthetic dislocation (IPD), in which the inner prosthetic femoral head disengages from the outer PE bearing, due to an abnormal PE

wear (7). However, the rate of this typically late complication (mean time to failure 8-11 years) encountered a 10 times reduction with the introduction of highly crosslinked PE (8). In a recent review made in 2017, De Martino et al. reported a low dislocation and IPD rate for DM THA both in primary surgery (0,9% and 0,7% respectively, mean 6.8 years follow-up) and in revision setting (3,3% and 1,3% respectively, mean 4,4 years follow-up) (6). Conversely, the use of DM implants in FNF treatment is much less studied in the literature, with few papers available in the latest years.

These studies showed good results at short-term follow-up with a lower rate of dislocation with respect to THA and an almost comparable rate of dislocation with respect to HA (ranging from 0 to 4,6%). Intra prosthetic dislocation seems also to be a negligible problem at short term with modern implants unless technical errors occur (18).

The aim of the present study is to evaluate at mid-term follow-up clinical and radiographic outcomes in a group of patients who underwent total hip replacement using a dual-mobility implant after femoral neck fracture, with particular focus on hip dislocation and intraprosthetic dislocation rate.

Materials and Methods

The present study was carried out on a population of patients treated for FNF at the Cattinara Hospital Orthopaedics and Traumatologic Unit in Trieste, Italy. All the patients who underwent total hip replacement using a dual-mobility implant (Fig. 1) from January 2010 to December 2012 were included in the study. The population in exam counted 53 patients, of whom 45 women and 8 men, with a mean age at the time of surgery of 76,76 years (range 54,96-88,34; median 77,5). Surgery was performed by experienced surgeons through a direct lateral approach to the hip with the patient supine.

Full weight bearing and hip mobilization with a physiotherapist started on the first day after surgery. Patients were discharged from hospital after mean 9 days and moved to rehabilitation facilities for mean three to four weeks.

At follow up 15 patients had died for causes not related to hip replacement and 8 resulted to be not contactable. Therefore, the study population counted 30 patients, of whom 24 women and 6 men for a total of 31 implants (one patient underwent bilateral DM THA for bilateral not simultaneous FNF fracture within the period of study).

The acetabular component was the same in all patients (AVANTAGE® Acetabulum System - Biomet). On the femoral side an uncemented stem was used in all cases (Biomet Taperloc in 21 cases and Biomet PPF in 10 cases). Both cobalt-chrome (Co-Cr) and ceramic heads were used, in 25 and 6 cases respectively.

Clinical evaluation was conducted at follow-up by two independent observers (A.M., M.C.) who were not involved in surgical treatment.

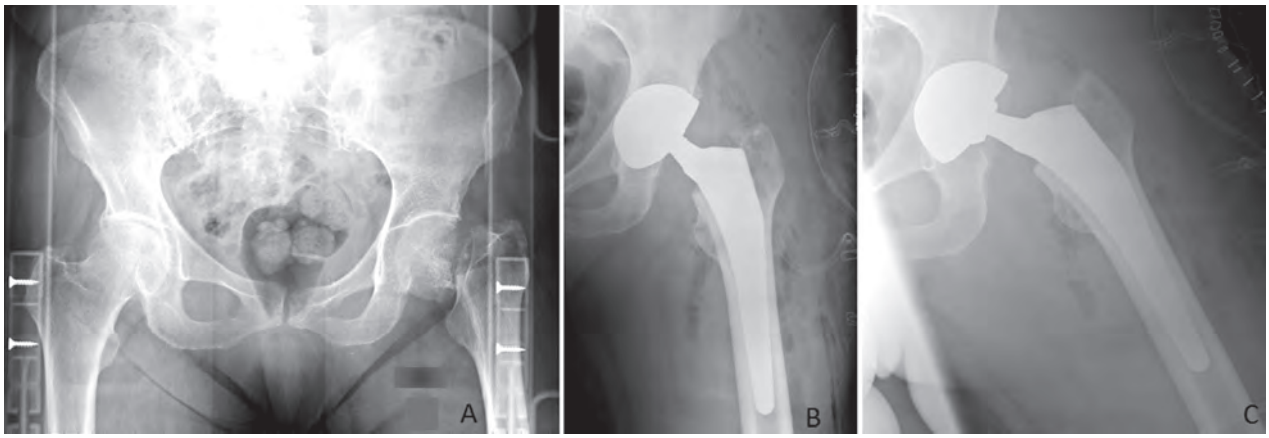

Figure 1. A 73 years old woman reported a left displaced FNF treated with a DM THA the day after trauma. A) pre-op radiograph showing left FNF B) AP and C) axial post-op radiographs of the prosthetic implant

Patients were examined between February and May 2017 with a mean follow-up of 5,67 years (range 4.30-7.68).

In all cases clinical and anamnestic evaluation were performed, recording relevant medical and neuromuscular comorbidities. Data regarding reintervention or post-operative complications such as periprosthetic fractures, surgical site infections and especially hip dislocations were collected. Subjective satisfaction of patients (rated as excellent, good, fair or bad) was registered. Objective evaluation of clinical results was carried out through the administration of the Harris Hip score (HHS) and the Oxford Hip Score (OHS). Radiographic evaluation was carried out at follow-up by the same independent observers (A.M., M.C.) on pelvis AP and Hip lateral views. The latest disposable radiographs were analyzed and compared to post-operative and intermediate radiographs. In 7 implants a recent radiographic exam was not disposable, therefore radiographic evaluation was conducted in 24 cases, with an average radiographic follow-up of 4,86 years (range 2-6,79). Radiographic examination was oriented to detect integration of the implant and eventual signs of loosening. Acetabular component osteointegration was evaluated applying Moore criteria: absence of radiolucent lines, presence of superolateral buttress, presence of medial stress-shielding, presence of radial trabecular pattern, presence of inferomedial buttress (22). Cup integration was considered when at least 3 criteria were met.

Results

At clinical follow up 6 patients (19.35%) resulted to be affected by relevant neuromuscular diseases, as advanced senile dementia, serious depression, hemiparesis after stroke, Parkinson disease (Tab. 1). Three of these patients were confined to bed or moved around by wheelchair.

No episodes of dislocation nor intraprosthetic dislocation were found.

Other postoperative complications were recorded in 3 cases on 31 implants (9,67%). In detail, a Vancouver Ag periprosthetic fracture, a superficial infection and a persistent thigh pain were registered. The latter patient rated her subjective satisfaction as fair, while the other 29 patients (30 implants) rated good or excellent.

Table 1. Neuromuscular comorbidities in the study population

Sex	Age	Pathologies
F	76	Parkinson's disease
F	75	Cerebral stroke (2 years before)
M	55	Multiple sclerosis
F	83	Severe cognitive impairment
F	76	Dementia and severe depression
M	75	Cerebral stroke

Harris Hip score showed a mean value of 81,22 (range 54,60-97,02).

Oxford Hip Score revealed a mean value of 37,37 (range 19-48).

Radiographic evaluation showed the presence of 4 Moore's criteria in 2 cases and 3 criteria in other 8 cases. None of the cases showed all 5 criteria. In 15 cases less than 3 criteria were noted (Fig. 2).

Thus, in 10 cases on 25 (40%) full osteointegration of the cup according to Moore was recorded.

There were no cases of clinical and radiographic signs of cup or stem loosening.

Table 2 summarizes clinical and radiographic results of the present study population.

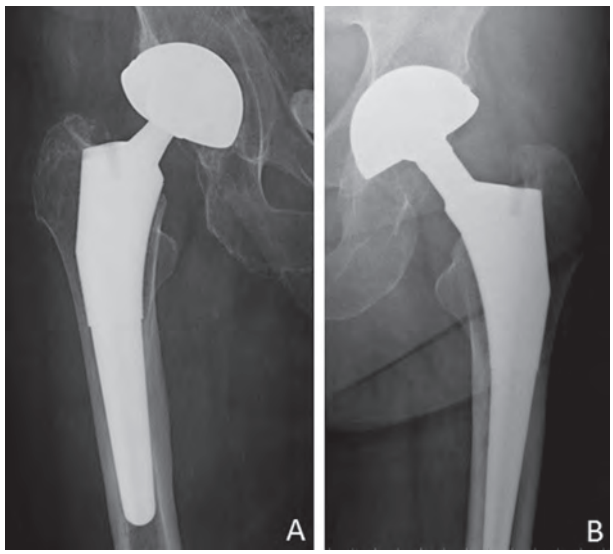

Figure 2. Five years follow-up radiographs of two different cases showing partial (A) and complete (B) cup integration according to Moore criteria. No sign of loosening is present

Table 2. Clinical and radiographic results of the population in exam

Pat.	HHS	OXS	Subjective outcome	Reintervention/Complications	Moore's criteria
1	79,01	39	Good	-	3
2	94,02	47	Excellent	-	3
3	97,02	47	Good	superficial infection	4
4	72,12	34	Good	-	2
5	66,85	33	Good	-	2
6	97,01	47	Excellent	-	2
7	86,65	43	Excellent	-	3
8	97	48	Excellent	-	3
9	95	48	Excellent	-	3
10	95	48	Excellent	-	2
11	55	22	Fair	persistent thigh pain	0
12	89	40	Excellent	-	3
13	89	48	Excellent	-	2
14	70,57	27	Good	-	2
15	74,49	31	Good	-	1
16	61,4	21	Good	-	3
17	64,7	23	Good	-	2
18	57,15	19	Good	-	-
19	74,9	34	Good	-	1
20	93,2	44	Excellent	-	4
21	85,2	44	Good	-	-
22	66,1	24	Good	-	2
23	88	37	Excellent	-	3
24	80,9	36	Excellent	-	1
24 bis	86,4	42	Excellent	-	2
25	54,6	26	Good	periprosthetic fracture (Vancouver Ag)	2
26	86,4	42	Good	-	-
27	92,7	45	Excellent	-	2
28	92,7	45	excellent	-	-
29	96	43	excellent	-	-
30	85	36	good	-	3

Discussion

There are few studies in the literature regarding DM THA for FNF treatment. However, some recent reports demonstrate a growing interest on this topic. In particular, the theoretical advantage of a very low dislocation rate together with good clinical results reported in the literature about OA might have lead to the growing indication for DM THA in FNF treatment. In a recent review (18) these studies were analyzed and compared with the literature about FNF treatment with other implants. The results in terms of patients demographic characteristics and mortality were in line with the literature (20, 23, 24). Conversely, a relevant amount of neuromuscular diseases and cognitive impairment incidence (up to 42% of cases) was recorded (14, 17). Nonetheless, Graversen et. al (19) conducted a study on 20 patients affected by dementia which the authors considered an ideal indication for DM THA. These data reflect the clinicians' choice to implant DM THA in patients at maximal risk of prosthetic dislocation. Moreover, data regarding dislocation rates for DM implants (0 to 4.6%) in FNF setting compare favorably with reported dislocation rates for conventional THA (ranging from 2% to 9%) (18, 20, 21). The present study data result to be in line with other reports in terms of patients demographic characteristics and mortality and percentage of neuromuscular or cognitive impairment. Moreover, both implant dislocation and intraprostethic dislocation rate resulted to be 0%, which confirms literature reports about DM THA for FNF treatment at short term follow-up (9, 11, 12, 15, 17-19).

Functional outcomes with DM THA resulted to be mainly good or excellent in most literature reports and comparable to other THA papers in FNF setting. (18, 25) Results of the present study in terms of subjective satisfaction and objective functional outcome at HHS and OHS confirmed to be comparable to the literature. Accordingly, surgical site complications in the present paper (9.67%) were in line with other literature reports (3.6% to 11.1%) (10, 13-18).

The main difference between the present study and other literature reports about FNF treatment with DM THA is follow-up. At our knowledge indeed no study reported in the literature about this topic exceeds 3 years follow-up. (18) The present study compares then favorably with the literature, with mean follow-up of 5,67 years (range 4.30-7.68). Thus, the present study confirms the good clinical results and the low dislocation rate with DM THA for FNF treatment at longer follow-up with respect to other literature reports.

Moreover, radiological data about cup integration should be considered. No such data about DM THA for FNF treatment are reported in literature at our knowledge, which renders comparison unfeasible. However, the low incidence of full osteointegration signs (40%) at 5.67 years follow-up is relevant. In the authors opinion it may be due to a lack of primary stability in osteoporotic bone as DM cups do not allow screws placement, which might have been beneficial in some cases. Nevertheless, neither clinical nor radiographic signs of loosening were noted. Future studies with larger series and longer follow-up may be needed in order to clarify this finding and quantify its clinical relevance.

The main limits of the present study are the retrospective design, the limited sample size and the relatively high drop-off.

Strengths of the study are the relatively long follow-up with respect to other literature reports and the radiographic evaluation.

Conclusions

The present study confirms the good clinical results, low complications and very low dislocation rate with DM THA for FNF treatment at longer follow-up with respect to other literature reports.

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Original article

Arthroscopic treatment of iliopsoas impingement syndrome after hip arthroplasty

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Summary. *Background and aim of the Work:* Groin pain after hip arthroplasty (HA) ranges from 0.4% to 18.3%. Defining the cause of groin pain after HA can be difficult. Iliopsoas impingement (IPI) has been reported to be the underlying cause of groin pain in up to 4.4% of cases. The purpose of this study is to present arthroscopic surgical outcomes in the treatment of IPI after HA. *Methods:* Between September 2013 and March 2018, 13 patients, 11 total hip arthroplasty (THA), 1 hip endoprosthesis and 1 total hip resurfacing affected by groin pain due to unceasing iliopsoas tendinopathy for impingement after HA were treated arthroscopically. The patients underwent to physical examination, blood analysis, hip X-rays, bone scintigraphy and CT assessment. We performed the arthroscopic OUT-IN access to hip joint in all patients. VAS scale, Harris Hip Score (HHS) and Medical Research Council (MRC) scale were performed before surgery and during follow up at 1-3-6-12 months. *Results:* After 10 months of mean follow-up, average HHS and MRC scale improved significantly from preoperatively to postoperatively. No complications arose in our case series. *Conclusions:* Hip arthroscopy after hip arthroplasty is supported in the literature for a variety of indications. Hip arthroscopy is a viable and reproducible technique in treatment of IPI, being less invasive than the classic open technique. This simple arthroscopic release provides satisfactory results and preserves HA function. Moreover an arthroscopic OUT-IN access proves good clinical outcomes, few complications and iatrogenic lesions. (www.actabiomedica.it)

Key words: groin pain, iliopsoas impingement, hip arthroplasty, hip arthroscopy, release

Background and aim of the Work

Groin pain after total hip replacement has a prevalence rate ranging from 0.4% to 18.3% (1). The potential causes of groin pain can be classified into intrinsic and extrinsic factors, being the former infections, aseptic failure, periprosthetic osteolysis, allergic reaction and pain due to lumbar spine pathology, abdominal, vascular or oncological injuries the latter (2-4).

Iliopsoas impingement (IPI) after hip arthroplasty (HA) is a potential cause of persistent groin pain and hip joint restriction often being underdiagnosed with a 4.4% frequency according to literature (5).

This condition was first reported by Postel et al. in 1975 (6) and then by Lasquene et al. in 1991 (7). Trousdale et al. in 1995 (8) recorded 2 cases of groin pain after total hip replacement treated with revision of the acetabular component after conservative treatment failure. During surgical revision procedure they found a frayed ileopsoas tendon anteriorly, impinged on the anterior rim of the acetabular component.

The iliopsoas is an complex musculo-tendinous unit (9) that inserts into the lesser trochanter. Psoas major tendon originates above of the inguinal ligament. It exits the pelvis distally, running over the anterior acetabular wall and over the hip joint with the medial iliacus bundle that unites into the psoas major

tendon. This complex musculo-tendinous unit acts as a powerful hip flexor and secondarily as a femoral rotator and stabilizer of the lumbar spine and pelvis.

IPI in HA usually happens because of tendon inflammation due to mechanical irritation with anteroinferior acetabular edge. However there are other less common causes inducing IPI. They can be divided into mechanical and not mechanical reasons (5, 10-12).

The main clinical sign of IPI is groin pain which started from the first month until a several years after HA (12, 13).

The diagnosis of IPI is composed of physical examination, x-rays (4, 8) and computed tomography (CT) images (14). Hip arthroscopy after hip arthroplasty is supported in the literature addressing several conditions (15). Hip arthroscopy can be a safe and effective method of treating IPI in hip arthroplasty and an useful diagnostic tool for further diagnostic investigation (15). The purpose of our study is to present arthroscopic surgical outcomes in the treatment of IPI after HA.

Methods

Between September 2013 and March 2018 we identified 13 patients, 11 total hip arthroplasty (THA), 1 hip endoprosthesis and 1 total hip resurfacing with a diagnosis of iliopsoas impingement. Nine patients were males and four were females, the mean age was of 65 years (range 47-82). The average time to onset of symptoms was 6 months after HA.

Seven THA were implanted in our department (Department of Orthopaedic Surgery, University Hospital of Udine, Udine, Italy). The diagnosis was based on clinical evidence and imaging.

The patients underwent physical examination, blood analysis, i.e white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), hip X-rays, bone scintigraphy (16) and CT assessment (14, 17). Initially, we excluded hip periprosthetic joint infection (PJI) following the diagnostic criteria for PJI that have been established (18).

Patients complained typical symptoms (4, 13, 19-21), severe groin pain when climbing stairs and getting in and out of a car (car sign) or bed from the first months after HA, often manually assisting elevation of the lower limb.

Physical examination showed tenderness on palpation in the groin area, groin pain with active hip flexion, especially straight leg raise against resistance, and on stretching of the the hip flexors, a positive iliopsoas contracture test.

The diagnosis of IPI was confirmed by x-rays including true lateral hip view (Fig. 1) and computed tomographic (CT) scans (Fig. 2) to demonstrate anteroinferior component prominence (4, 14).

We performed arthroscopic tendon release in all screened patients after 6 months of no effective conservative treatment (10, 22) with <8 mm of acetabular component prominence (5).

Visual Analogue Scale (VAS) (23) for pain evaluation, Harris Hip Score (HHS) (24) for hip function and Medical Research Council (MRC) scale (25) for grading the patient's muscle strength on a 0 to 5 scale were performed before surgery and during follow up at 1-3-6-12 months after surgery.

Hip arthroscopy was performed in all patients with extra-capsular (OUT-IN) access (26) and tendon release was carried out according to Wettstein technique (27) in the impingement zone on the anterior rim of the acetabular component.

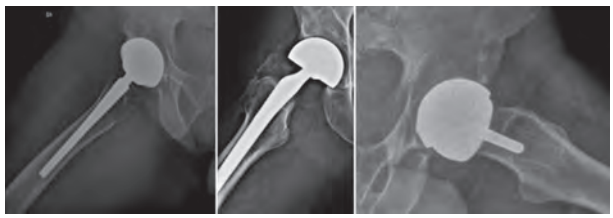

Figure 1. Preoperative true lateral view radiographs of THA (A),Hip endoprosthesis (B), total hip resurfacing (C)

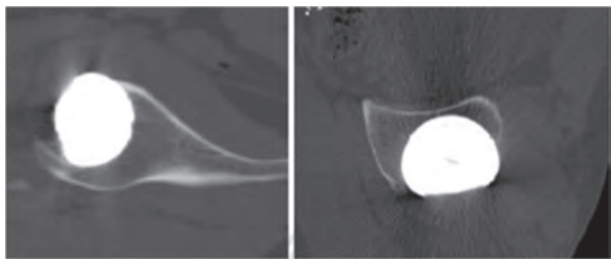

Figure 2. CT scans tries antero-inferior component prominence

In the post-operative period we recommend no weight-bearing and assisted rehabilitation program performing only passive hip mobility for 2 weeks. Active hip flexion with straight leg raise had to be avoided for 4 weeks as well.

Results

All 13 patients had a negative preoperative assessment for signs of infection or loosening.

Preoperative clinical evaluation showed the average HHS of 66.8 points (range 48.9-81.8), the average MRC scale 3.6 grade (range 3-4), the mean hip flexion of 95° (range 80°-100°), the average VAS 3.6 points (range 2-6).

Preoperative imaging assessment proved acetabular cup prominence due to poor acetabular cup anteversion in THA, to large cup of hip endoprosthesis and prominent and medialized large femoral head on the femoral neck in total hip resurfacing.

In all patients, arthroscopic examination revealed iliopsoas kneeling and mechanical irritation with antero-inferior acetabular edge (Fig. 3). The tendon release was performed using the technique described above in all patients (Fig. 4). One patient with hip endoprosthesis had large periprosthetic ossification, which was removed.

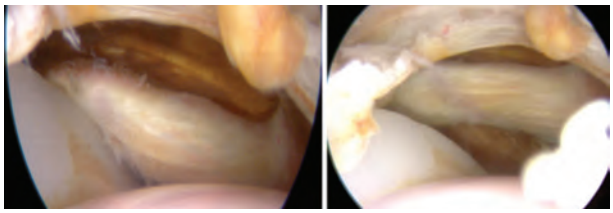

Figure 3. Arthroscopic view shows iliopsoas kneeling and mechanical irritation with antero-inferior acetabular edge

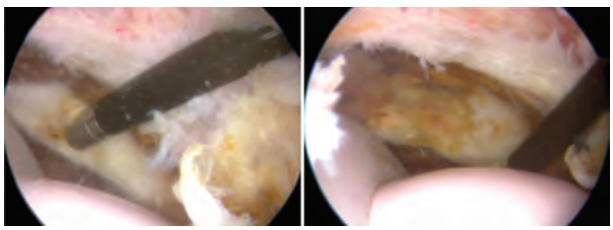

Figure 4. Arthroscopic psoas release in the impingement zone on the anterior rim of the acetabular component

During post-operative recovery patients had no complications and the hospital stay was 1 day. Patients underwent 1-3-6-12 months follow-up.

All patients had immediately improvement in pain and function, no complications arose during follow-up period and evaluation of their satisfaction degree revealed to be high. For these reasons many patients did not completely respect the follow-up monitoring.

After 10 months of mean follow-up (3-12), average HHS, MRC scale, hip flexion and VAS improved significantly from preoperatively to postoperatively to 85 points (range 80-95), 4.7 grade (range 3-5), 105°(range 90°-120°) 1 point (range 0-3), respectively.

Conclusions

Pain in the groin area is due to several injuries and often different pathologies overlap becoming, sometimes, a real diagnostic challenge (21, 28). Iliopsoas-related groin pain generally occur with pain on resisted hip flexion and/or pain on stretching the hip flexors (21). Iliopsoas impingement may be a cause for persistent groin pain after hip arthroplasty (HA). Other possible and more frequent causes for HA failure should of course be excluded. Among all, PJI must be early excluded. Laboratory tests (white blood cell count, ESR, CRP), radiographs and bone scintigraphy can help to rule out this diagnosis (16, 29, 30). IPI after HA is more frequent than previously assumed. This condition is very disabling; severe groin pain appears in the first months after hip replacement during hip flexion against resistance and stretching of the iliopsoas tendon (4, 20, 21).

Iliopsoas tendon sheath corticosteroid and anesthetic agent injections represents a valuable diagnostic test with an immediate therapeutic effect. Conservative treatment should always be attempted for at least 6 months (31, 32).

Physical therapy, non-steroidal anti-inflammatory drugs (NSAIDs), and local corticosteroid or botulinum toxin A injections are nonoperative options to relieve pain at the beginning or in the long term in patients who can not undergo surgery (10, 22).

Outcomes reported a pain average improvement of 50% after one year (31, 32). The indication for sur-

gical treatment was recommended after unsuccessful conservative treatment, with the typical clinical signs and symptoms, a positive local anesthesia test and radiological signs for an anterior prominent acetabular component (5). Acetabular revision is associated with high complication and revision rates, but when cup prominence is ≥8mm acetabular revision is recommended with a high success rate of groin pain resolution and excellent clinical outcomes (5, 31). On the other hand, patients with <8 mm of acetabular prominence can benefit from the iliopsoas tenotomy (5). Iliopsoas tenotomy can be performed either by open technique or arthroscopic release. Open tenotomy allows evaluation of component positioning, stability of the acetabular component and other abnormal processes that might contribute to the patient 's groin pain. The success rate ranges between 75% and 91.5% (2). However open tenotomy is more invasive, requiring a longer hospital stay and recovery period. It has a higher risk of implant infection or bearing surface damage than the arthroscopic release (10), whereas arthroscopic treatment of IPI after hip replacement has about 94% of success rate (2). In our case series, all patients affected by IPI had <8 mm of acetabular anteroinferior prominence on true lateral hip radiographs. Another topic debated is the size of the head in addition to the acetabular protrusion as a cause of groin pain after THA.

Varadarajan et al. (33) assessed the contact between the femoral head and the iliopsoas complex with heads of various sizes. This contact was visually observed following dissection and THA implantation, as well as the "ileopsoas tenting" caused by the traditional heads. The use of small diameter femoral heads relieves hip pain but increases the risk of dislocation. Therefore, in order to use larger diameter heads, it is necessary to use heads with the most anatomical peripheral profile in its lower half.

In our case series, all patients experienced immediately improvement in pain and function, no complications arose and everyone was highly satisfied.

Analyzing the prosthesis with IPI, we had 7 Collum Femoris Preserving (CFP) (34) THA implanted in our surgical department despite we followed surgical technique for CFP implantation to avoid this complication. The acetabular cup of this implant has a middle-caudal groove to limits the possibility of the impingement with psoas tendon and femoral nerve. In addition we had been careful not to overflow the collar component more than 1-2 mm to avoid collar impingement with the psoas tendon (34).

Pain incidence by total hip endoprosthesis implantation is around 1-17.6% depending on the type of prosthesis. Few reports describe IPI as a cause of pain following implantation of an endoprosthesis in total hip arthroplasty (35). We treated successfully one patient for IPI following hip endoprosthesis with large cup component.

The rate of groin pain following hip resurfacing is about 18%, a greater rate than conventional THA (12, 36). In hip resurfacing the possible causes of pain are hypersensitivity to metal-on-metal bearing surfaces or greater impingement of the psoas tendon across the larger femoral heads used (37). Our patient experienced moderate groin pain that was relieved after arthroscopic release. The cup is not prominent anteriorly, but the large femoral head is prominent and medialized on the femoral neck. Cobb et al. (38) suggested that IPI may be caused by the oversized apron of the metal head that extends well beyond the limit of the normal femoral head. This zone is used as a fulcrum by the tendon of iliopsoas in full extension. Then in total hip resurfacing if the centre of the acetabulum is moved forward, or the size of the head is increased, IPI is almost assured.

Hip arthroscopy is a viable and reproducible technique in treatment of IPI, being less invasive than the classic open technique. Also it is a valuable diagnostic tool to address the diagnosis, if metallosis or infection were detected (15).

The arthroscopic iliopsoas tendon release was performed in the impingement zone on the anterior rim of the acetabular component to avoid loss of hip flexion strength that can be caused by its tenotomy at trochanteric insertion (2, 27, 39, 40).

Moreover, two recent case series showed good outcomes in terms of pain and recovery of muscle strength with endoscopic tenotomy at the lesser trochanter (10, 41).

This simple arthroscopic release provides satisfactory results and preserves HA function with a low rate of complications.

Our experience in arthroscopic treatment of IPI after hip arthroplasty agrees with the literature that present small cases series (between 7 and 35 cases) showing excellent results and no complications (2, 10, 13, 42).

Guicherd W et al. (41) presents the only prospective multicenter case series (64 cases performed in 8 centers) that shows two early complications after arthroscopic iliopsoas relesase: one case of anterior dislocation in transcapsular tenotomy and one case of compressive hematoma affecting the peroneal nerve.

Our arthroscopic extracapsular access (OUT-IN) to the hip, as previously published (26), allows some important advantages. The introduction of the instruments takes place after the capsulotomy under arthroscopic vision, away from the prosthesis avoiding damage. Hip distraction during the arthroscopic accesses is not necessary as well as the use of X-ray, which prevents patient and surgeons exposure to ionizing radiations, reduces surgical timing and risk of hip joint infection.

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Original article

Locking plate fixation in pediatric femur fracture: evaluation of the outcomes in our experience

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Summary. *Background and Aim:* Femoral shaft fracture is a common traumatic musculoskeletal injures in pediatric population. The treatment of diaphyseal femoral fractures depends on age patient and pattern fracture. We present our record about the use of locking plate fixation and their outcomes. *Method:* We conduct a retrospective analysis in 22 patients, surgically treated for 26 diaphyseal femur fracture between 2008 and 2013. The mean age was 13 years. All the patients underwent a clinical and radiological follow-up for two years. We recorded time to weight bearing, time to union, complication (malalignment, dysmetria, infection), time to resumption to sport, plate removal, parents' satisfaction. *Results:* All the patients had a minimal clinical e radiological follow-up of 24 months. The average fracture healing time was of 7.4 weeks. All the patients had a full hip and knee range of movements. Fifteen patients developed minor malalignment (varo-valgus or procurvatum femur) without clinical effects. No cases of infections. The mean time to a full weight bearing was 12 weeks and the return to sportive activity was 24 weeks. Four patients required a plate and screws removal. The average result of parents' satisfaction was 8/10. *Conclusions:* Locking plate fixation is to be considered a successful way of treatment for pediatric femur fractures, especially in patients older than 6 years, head-injured or in the treatment of polytrauma. The anatomic and functional outcomes are comparable to those of other fixation techniques for this kind of fracture. (www.actabiomedica.it)

Key words: pediatric fracture, femur, locking plate, malalignment

Introduction

Femur fractures are frequent in the pediatric and adolescent population. Femoral shaft fracture is one of the most common traumatic musculoskeletal injuries requiring hospitalization in young patients (1).

The peak of incidence occurs among 12 years old, at a younger age in the female and older age in the male. There is a male-to-female incidence ratio of 1.5. The most common mechanism of this type of injury was falling and abuse in the younger patients and motor/bicycle accidents in the older ones (2-4).

Among the treatments of fractures of the pediatric femur, we include surgical and non-surgical treatments. Among the non-surgical treatments, we mention the use of traction and Spica casting. These treatments are reserved for patients with fractures with shortening less than 2 cm and under 5 years of age (5,6). These treatments show good clinical and radiological results at mid-long-term and represent the gold standard in this kind of pediatric population (7). These treatments, however, are not indicated in particular conditions such as: polytrauma, head injury, unstable fracture, shortening more than 2 cm or non-reducible fracture (8).

As the most frequent pathological mechanism in adolescent patients is a result of high-energy trauma, non-surgical treatments are often contraindicated.

Among the surgical treatments, the most frequently used are external fixation, intramedullary nailing with rigid or flexible nail and plate fixation (9).

In the correct indication, plate fixation offers several advantages: excellent stability, fully early motion, allows to manage proximal and distal fractures, and does not need a cast in post-operative periods. Moreover, this technique could be used in fragile adolescents, such as adolescents with polytrauma or in case of severe head injury (10, 11).

The purpose of our study is to present our report in the use of plate fixation in the diaphyseal femoral fractures in adolescences.

Materials and Methods

We conducted a retrospective analysis in 22 patients, surgically treated for 26 diaphyseal femur fracture in our center between 2008 and 2013. The average age of surgery was 13 years old (range: 8-16 years).

The inclusion criteria were: diaphyseal femur fracture, age under 18 years old.

The exclusion criteria were: open fracture.

All the baseline characteristics were obtained from the patient's recovery schedule. Clinical charts were reviewed to record follow-up data such as time to weight bearing, time to union, complication, time to resumption to sport and plate removal.

The radiographic review included a review of the initial fracture radiograph to record fracture

location and pattern (AO pediatrics classification). We also included post-operative radiographs and later check-ups to judge the bone healing.

At one year's follow-up, all the patients underwent a weight-bearing lower limbs radiography to analyze the lower limb axis, varo-valgus and rotation defect, asymmetry and state of plate and screws.

Surgical procedure

Surgery was performed under general anesthesia with the patient in supine position on the operating table. An incision of different length, according to the specific fracture pattern, was made along an imaginary line between the greater trochanter and the lateral epicondyle. The fascia lata was incised and split parallel to skin incision, the vastus lateralis was split, elevated from the intermuscular septum and retracted anteromedially. The femoral shaft was then extraperiosteally exposed. The fracture was provisionally reduced by manual traction or bone reduction forceps. Particular care should be taken in order to restore rotational alignment and length. Definitive fixation was performed with a pre-contoured LC-DC plate with 3 screws proximal and 3 screws distal to the fracture site. An X-ray check was required at the end of the procedure. Patients were clinically and radiologically followed up at week 1 and week 4 after surgery. Patients were mobilized without weight-bearing until the 4th-week X-ray follow-up. A progressive to full weight-bearing was allowed from 6th to 9th week after surgery according to fracture type, radiographic results and associated injuries.

Result

We enrolled 22 patients, 6 female and 16 males, affected by 26 femoral shaft fractures. The right femur was involved in 18 cases and there was 4 bilateral femoral fracture. The average age was 13 years old (range: 8-16 years). The most frequent injury mechanism was falls and vehicle accidents. All patients were admitted to our emergency care department with a diagnosis of "polytrauma". Three patients had spleen lesions, one patient had a liver lesions; all these injuries did not require surgery. Ten patients had a mild-to-severe head trauma. Three patients were affected by epilepsy and developed the fracture following an epileptic attack. Two patients had a previous femur fracture treated by TENs reduction but developed a new fracture (Fig. 1). One patient was affected by myelomeningocele and bone dysplasia and developed a spontaneous fracture; this patient had never walked, even before the fracture.

According to AO pediatrics classifications were treated 12 type 32.D/4.1, 4 type 32.D/4.2, 7 type 32.D/5.1, 3 type 32.D/5.2. Four patients were initially treated with external fixation than converted to plate fixation after 7 days and clinical stabilization.

All the patients had a minimum follow-up, clinical and radiological, of 5 years.

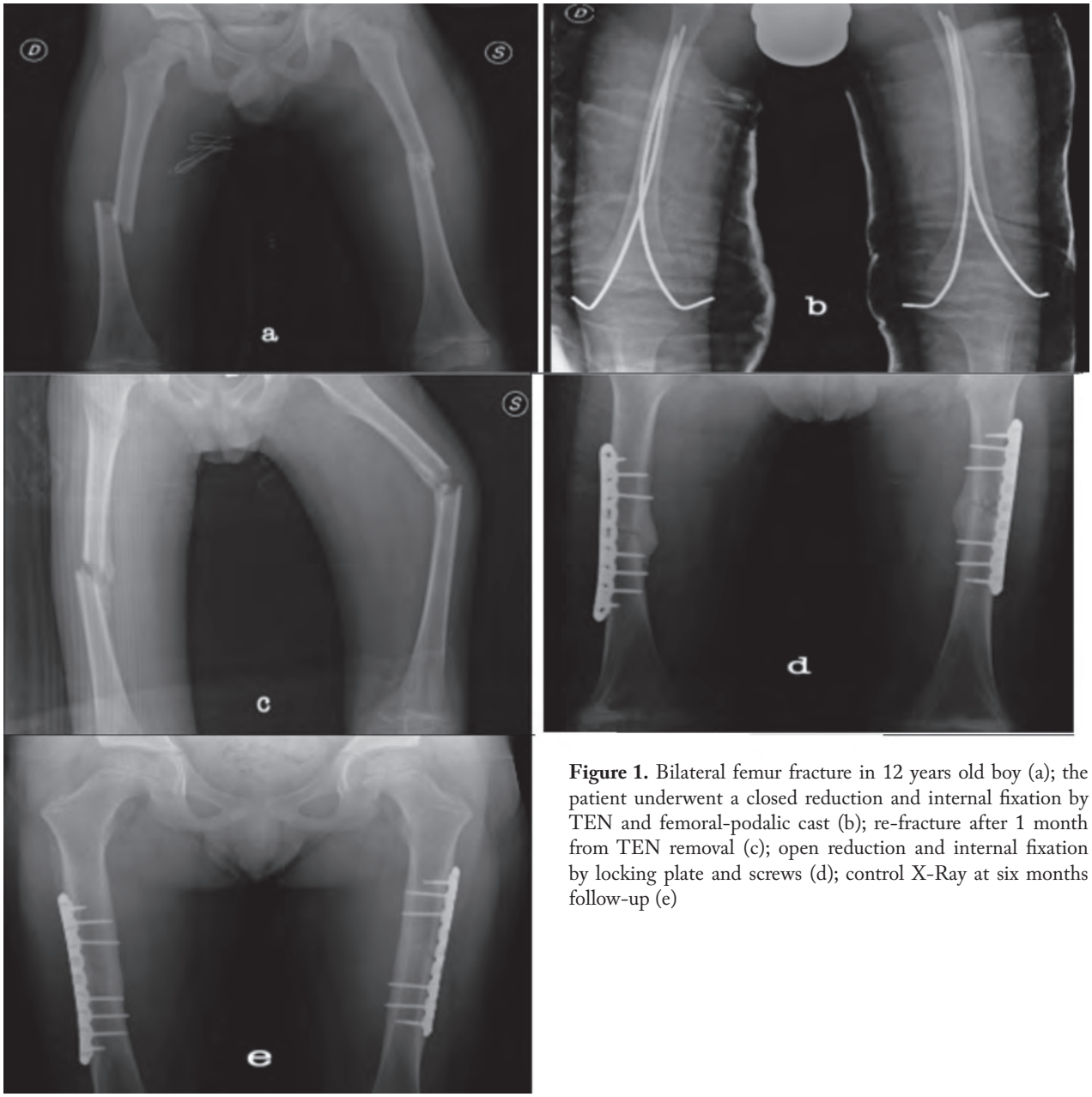

Figure 1. Bilateral femur fracture in 12 years old boy (a); the patient underwent a closed reduction and internal fixation by TEN and femoral-podalic cast (b); re-fracture after 1 month from TEN removal (c); open reduction and internal fixation by locking plate and screws (d); control X-Ray at six months follow-up (e)

At the last follow-up, excluded the myelomeningocele syndromic patient, all the patients had a full hip and knee range of movements. Two patients had a lengthening below 2 cm, three patients had a hypometria below 2 cm, only one patient had a lengthening higher than 2 cm corrected by a heel. We founded one case of varus knee below 5 grades, three cases of valgus knee below 5 grades and five cases of procurvatum femur without clinical effects.

During the follow-up no cases of infections or wound complication; one patient affected by a bilateral fracture, developed a delay of consolidation of the fracture, with a fully recover in 8 months.

The average fracture healing time was of 7.4 weeks (range: 6-10 weeks).

The average time to a full weight bearing was 12 weeks and the return to sportive activity was 24 weeks.

Four patients required a plate and screws removal after 1 year of surgery because of local discomfort.

We submitted to all the parents a scale to evaluate the satisfaction of the treatment (0 very low, 10 very satisfied): the average result was 8/10.

Discussion

The treatment of diaphyseal femoral fractures in pediatric patients has long been debated. The American Academy of Orthopedic Surgeons released guidelines for the treatment of these fractures in 2010. Given the low quality of the studies in the literature there are only two second level recommendations: in the case of femoral shaft fractures in patients aged less than 36 months the possibility of abuse should always be evaluated (2nd degree evidence, recommendation A); in the case of fractures with shortening less than 2 cm in patients younger than 5 years a Spica-casting should be used (2nd degree evidence, recommendation B) (5).

Conservative treatment remains the primary approach considering the high healing power and remodeling aptitude in children age six months to five years (12). These approaches have shown good mid-to-long-term clinical and radiological result; callus formation occurs quickly, and there are few long-term consequences observed (13). Neonate and infant (below 5 years old) should be treated with a Spica casting for up to 3 weeks (14). In this patient non-invasive treatment is still preferred, such as skin traction, eventually followed by hip Spica-casting. Fifteen degrees of varus or valgus angulation and 25 degrees of flexion or extension may be tolerated (15).

On the other hand, conservative treatments present some important limitation: skin traction needed prolonged hospitalization, patient and parents' discomfort, difficult management in hygienic care and long weight-bearing restrictions (14).

Considering these limitations, surgical treatments are progressively increased in the last years. Surgical treatments are first choice in patients suffering from multiple traumas, especially in head injury, and in fractures with significant deformities.

A recent systematic review compared the clinical and radiographic results and the incidence of complications in patients with conservatively or surgically treated (Titanium Elastic Nail or plate fixation). Patients who underwent surgery showed a better clinical outcome with a lower risk of non-union (11.5% vs. 8.1%), on the other hand they had a higher risk of complications (1% vs 4%). The authors, however, conclude that the data in the literature are burdened by heavy biases that do not allow a good quality statistical analysis and, so, to draw adequate conclusions (12).

Among the surgical treatment Titanium Elastic Nail (TEN) showed to be safe and useful in the management of isolated femoral fractures in pediatric population older than six years and under 45 kg of weight (8, 16).

Plate fixation provides excellent stability (17) and to manage proximal, medial and distal fractures. This kind of surgery allowed a full early motion, good mobility, easy hygienic management. Various studies have demonstrated the usefulness of plating in multiple injury, in particular head trauma (10). On the other hand, this surgery can involve significant blood loss and longer operative time (compared to TEN) (18, 19); other complication could be delayed union, scar related problems, screw and plate prominence, femoral varo-valgus and rotation deformity and exceptionally infections (6). A review about treatment options in midshaft femur fractures reported only 1 infection in 142 fractures fixed by plating (9).

Kregor et al reported 12 multiply injured children affected by shaft femur fracture treated by plating; all fractures healed, there were no angular deformities and no infections were observed, overgrowth could occur but asymptomatic (10). Similar results were reported by Hedequist et al. in their paper: 32 patients, 6 months to 5 years old, were treated with plate fixation, all the patients gained a full weight bearing in an average time of 75 days, all fractures united with an anatomic alignment, among the complication there were one valgus angulation of 12 degrees, and one distal end of the plate fracture (20). Fyodorov et al demonstrated good outcome also in non-polytrauma patients with a record of 23 uncomplicated femoral fractures in children between 8 and 12 years old (21).

The results of our series are overlapping with the literature. Any rotational or varus-valgus defects are usually well tolerated and not require further treat-

ment. The development of hypometria or lengthening is partly compensated during growth and not require further surgical treatments. The evaluation of parents' satisfaction is fundamental to better understand the simplicity of management of these patients at home. In the literature there are no guidelines regarding the need of plate removal; this choice is left to the operator experience.

The use of plate fixation using minimally invasive plate osteosynthesis (MIPO) technique has increased over the last ten years (20,22-24). MIPO technique allowed to increased stability, small incisions and preserved the blood supply (23), moreover decreased risk of infection (22), operative time and blood loss (the difference was not clinically relevant as there was no difference in the need for blood transfusions) (24). About the complications the MIPO technique showed an increase in rotational asymmetry that not require corrective treatment (24) and rarely refracture following plate removal (25). Regarding plate removal, a more extensive procedure could be necessary due to bony overgrowth above the plate (6, 26).

Conclusion

Locking plate fixation is to be considered a successful way of treatment for pediatric femur fractures, especially in patients older than 6 years. The evaluated outcomes in this paper are comparable to those of other fixation techniques for this kind of fracture. Plating has generally been reserved for head-injured children or in the treatment of polytrauma with thoracic trauma.

Recently, there has been a considerable trend in minimally invasive plate osteosynthesis. In the right circumstances and indications, locking plate is still an effective method of fixation of pediatric femur fractures in terms of anatomic and functional outcomes.

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Original article

Role of low field MRI in detecting knee lesions

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Summary. *Objective:* The aim of this work is to evaluate the diagnostic accuracy of 0.3T sectoral MR imaging, compared with arthroscopy, for meniscal, cruciate ligaments and chondral knee lesions. *Materials and Methods:* We conducted a retrospective study analyzing all the consecutive knees subjected to arthroscopy at our institution between January 2014 and June 2017 and preceded within 3 months by knee MR examination at our institution with 0.3 T equipment. Patients with history of a new trauma in the time interval between MR exam and arthroscopy were excluded from the study. Two independent experienced radiologists evaluated in double blind the MR findings of menisci, cruciate ligaments and articular cartilage. Both radiological findings were independently compared with those of the arthroscopic report considered as gold standard. For each of the examined targets we calculated the following parameters: sensitivity, specificity, accuracy, positive and negative predictive value; interobserver concordance statistically calculated using Cohen's Kappa test. *Results:* 214 knees (95R/119L) of 214 patients (143M/71F) aged from 18 to 72 years (mean 44) were included and analyzed. We found a good diagnostic accuracy of the low field MR in identifying the injuries of the menisci (93%) and the crossed ligaments (96%), but a lower accuracy for the articular cartilage (85%). Sensitivity resulted 90% for menisci, 73% for ligaments and 58% for cartilage. Specificity was 91% for menisci, 97% for ligaments and 92% for cartilage. Inter-observer concordance resulted to be excellent for cruciate ligaments (K of Cohen's test = 0.832), good (K = 0.768) for menisci, modest to moderate for articular cartilage (K from 0.236 to 0.389) with worse concordance for tibial cartilage. *Conclusions:* Low-field MR sectoral device with dedicated joint equipment confirms its diagnostic reliability for the evaluation of meniscal and cruciate ligaments lesions but is weak in evaluating low grade chondral lesions. (www.actabiomedica.it)

Key words: Low field MRI, MR, Magnetic Resonance, knee, arthroscopy, meniscal lesion, chondral lesion, ligament lesion, diagnostic accuracy, cartilage, 0.3T MR, sensitivity, specificity, predictive value, concordance

List of abbreviations:
MR = Magnetic Resonance
MRI = Magnetic Resonance Imaging
T = Tesla
STIR = Short Tau Inversion Recovery
GRE T1 = GRadient Echo T1
SE T1 = Spin Echo T1
FSE T2 = Fast Spin Echo T2
AMA = American Medical Association
SS = Sensitivity
SP = Specificity
ACC = Accuracy
PPV = Positive Predictive Value
NPV = Negative Predictive Value
ACL = Anterior Cruciate Ligament
PCL = Posterior Cruciate Ligament

* Both authors contributed equally to the paper and thus are both to be considered 1st author

Introduction

Magnetic Resonance (MR) is the best non-invasive imaging method for evaluating the anatomical structures of the knee (1); its diagnostic accuracy, which varies according to the equipment used and the anatomical tissue studied, can be comparable to that of arthroscopy (2-6), considered the gold standard in the diagnostic evaluation of meniscal and cruciate ligaments lesions.

Most of the scientific studies aimed at assessing the sensitivity and specificity of the MR were carried out with high intensity field equipment (>1T) but even low-field studies (<0.5T) (3,7,8) have shown an overlapping diagnostic reliability concerning the pathology of meniscal fibrocartilages and cruciate ligaments.

High intensity field MR devices provide better signal/noise ratio, better contrast and better spatial resolution with faster acquisition time than low magnetic fields (8); however, considering the lower purchase and maintenance costs, the ease of installation in not too wide environments (9) and the diagnostic performance for ligaments and menisci similar to that of the high-intensity field MR (8), it would be generally desirable to use low-field equipment.

Moreover, despite the availability of high-intensity field "open" machines, low-intensity sectoral equipment is preferred by claustrophobic patients and children for whom no sedation is required (10).

To date the reliability of the information about the articular cartilage condition obtained with low intensity magnetic fields is still doubtful; in particular mild chondral lesions seem to be not easy to be detected by these low field devices (3).

Purpose

The primary aim of this work was to evaluate the diagnostic accuracy of a low-field (0.3T) sectoral MR device, compared with arthroscopy, for meniscal, cruciate ligaments and chondral knee lesions. Secondary aims were the estimation of sensitivity, specificity, positive and negative predictive values and inter-observer concordance.

Materials and methods

We conducted a retrospective study analyzing all the knees consecutively subjected to arthroscopy at our institution between January 2014 and June 2017 and preceded by knee MR examination within 90 days from arthroscopy at our institution with 0.3 T equipment with dedicated coil (Oscan, Esaote, Genova, Italy). The MR examinations were performed with the knee in slight flexion and intra-rotation with the STIR, GRE T1, SE T1, FSE T2 acquisitions in the three planes of the space (Table 1).

Exclusion criteria concerned all the patients examined by other MR devices, to have a uniform MR evaluation; moreover patients undergone arthroscopy more than 90 days after MR and patients with history of a new trauma in the time interval between MR examination and arthroscopy were also excluded from the study to avoid possible modifications of the tissues which could vary and false the MR-Arthroscopy comparison.

All patients included in the study expressed a written consent to undergo MR examination and arthroscopy and to treat personal data.

Table 1. 0,3 T MR parameters

	TR	TE	Etl	Thickness (mm)	Gap (mm)	Matrix	Nex
SE T1	1040	24	1	4	0,4	256x256	1
FSE T2	5460	100	10	4	0,4	256x256	2
GRE T1	505	16	1	4	0,4	512x512	2
STIR*	1920	25	1	4	0,4	256x256	1

*TI = 90

TR: repetition time; TE: echo time; Etl: long echo train lenght; Gap: slice intervals; Nex: number of excitation.

Two independent experienced radiologists evaluated, in blind of the other radiologist and of the arthroscopic report, the MR findings of the menisci, the cruciate ligaments and the articular cartilage, classifying the lesions according respectively to Lotysch for menisci (3 degrees) (Table 2) (11), American Medical Association (AMA) for ligaments (3 degrees) (Table 3) (12), and Outerbridge for cartilage (4 degrees) (Table 4) (13); moreover, in evaluating the cartilage, the articular surfaces were divided into medial and lateral condyle, medial and lateral tibial plateau, femoral trochlea and patella.

Table 2. Lotysch meniscus injuries grading

Grading	Aspect
I	small focal area of hyperintensity, no extension to the articular surface
II	linear areas of hyperintensity, no extension to the articular surface
III	abnormal hyperintensity extends to at least one articular surface (superior or inferior), and is referred as a definite meniscal tear

Table 3. AMA ligament injury classification

Grade	Description
I	Mild, minor tearing of ligament fibers and no demonstrable increase in translation on examination
II	Moderate, partial tear of the ligament without complete disruption, with a slight to moderate increased translation upon examination
III	Severe, complete tear of the ligament, with a marked increase in translation upon examination

Table 4. Outerbridge articular cartilage defect grading

Grade	Description
I	Focal areas of hyperintensity with an intact surface
II	Shallow superficial ulceration, fibrillation, or fissuring involving less than 50% of the depth of the articular surface
III	Deep ulceration, fibrillation, fissuring, or a chondral flap involving 50% or more of the depth of the articular cartilage without exposure of subchondral bone.
IV	Full-thickness chondral wear with exposure of subchondral bone

Both series of radiological findings were independently compared with those of the arthroscopic report considered as gold standard and for each of the examined targets the following parameters were calculated:

- Sensitivity (SS): the percentage of patients for whom the diagnosis detected by MR was confirmed by arthroscopy
- Specificity (SP): the percentage of patients for whom the negative diagnosis detected by MR was confirmed by arthroscopy
- Accuracy (ACC): the percentage of patients for whom the MR scan diagnosis was found to be the same at arthroscopy;
- Positive Predictive Value (PPV): percentage of patients with positive MR findings also positive at arthroscopy;
- Negative Predictive Value (NPV): the percentage of patients with negative MR findings confirmed as negative by arthroscopy;
- Inter-observer concordance statistically calculated using Cohen's K test.

Results

Sample characteristics

214 knees, 95 (44 %) right and 119 (56 %) left, of 214 patients, 143 (67 %) males and 71 (33 %) females, aged from 18 to 72 years (mean 44) were included and analyzed.

Arthroscopic findings

The following lesions were found at the arthroscopic inspection:

- 155 medial meniscal lesions (Figures 1 and 2), 53 lateral meniscal lesions;
- 42 Anterior Cruciate Ligament (ACL) lesions (Figure 3), 3 Posterior Cruciate Ligament lesions (PCL) (Figure 4);
- 242 cartilage lesions (Figure 5) of which 30 patellar, 70 tibial and 142 femoral-trochlear (Figure 1).

MR findings

At MRI the *first reader* recognized:

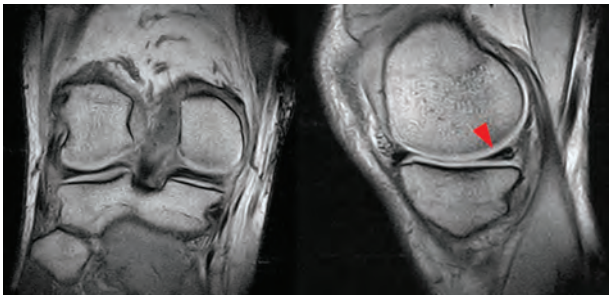

Figure 1. Longitudinal lesion of the medial meniscus posterior horn

- 194/208 meniscal lesions, misunderstanding 14 (9 of lateral meniscus and 5 of medial meniscus);
- 41/45 cruciate ligaments lesion, misunderstanding 4 (3 of the ACL and 1 of the PCL);
- 136/242 cartilage injuries, misunderstanding 106 (9 on the patella, 49 on the tibia and 48 on the femur) (Figure 2 and 3).

The *second MR reader* detected:

- 185/208 meniscal lesions, misunderstanding 23 (3 of the lateral meniscus and 20 of the medial meniscus);
- 37/45 injuries of the cruciate ligaments, misunderstanding 8 (7 for the ACL and 1 for the PCL);

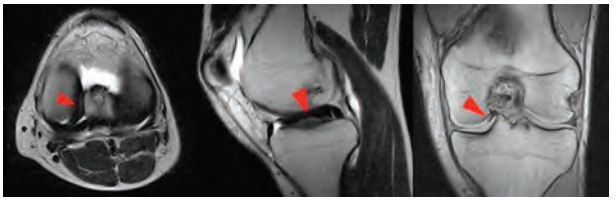

Figure 2. Bucket-Handle lesion of the medial meniscus

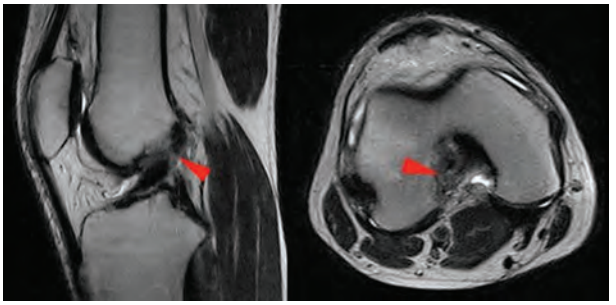

Figure 3. Full proximal (femoral) lesion of the anterior cruciate ligament

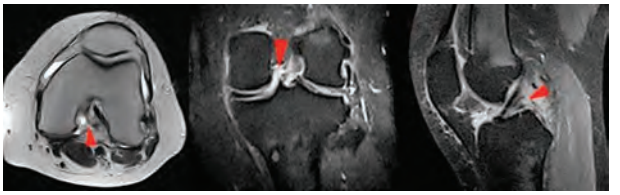

Figure 4. Full lesion of the posterior cruciate ligament

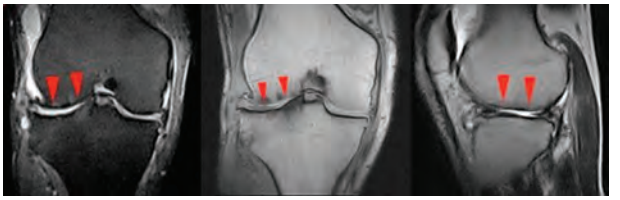

Figure 5. III-IV degree chondropathy of the lateral compartment

- 126/242 cartilage injuries, misunderstanding 116 (7 on the patella, 62 on the tibia and 54 on the femur) (Figure 4 and 5).

MR-Arthroscopy comparison (Table 5)

- *Meniscal* injuries revealed 90% of sensitivity, 91% specificity and a diagnostic accuracy of 93% (mean values between the two observers vs arthroscopy);
- crossed *ligaments* lesions showed 73% sensitivity and 97% specificity with an accuracy of 96%;
- for articular *cartilage* we obtained a mean sensitivity of 58%, 92% specificity and 85% diagnostic accuracy: in particular 82% patella, 90% tibia and 84% femur.

Inter-observer concordance resulted to be excellent for cruciate *ligaments* (K of Cohen's test = 0.832), good (K = 0.768) for *menisci*, modest to moderate for articular *cartilage* (K ranging from 0.236 to 0.389) with worse concordance for tibial cartilage.

Discussion

Over the years, with the evolution of machines and study protocols, MR has been confirmed as a non-invasive and highly sensitive instrument in the evalua-

Table 5. Results of the comparison between MR and arthroscopy findings.

	SS1	SS2	SP1	SP2	PPV1	PPV2	NPV1	NPV2	ACC1	ACC2
Medial Meniscus	97	87	85	97	95	87	90	97	94	95
Lateral Meniscus	83	94	97	83	90	94	95	85	93	91
PCL	67	50	100	99	100	50	100	99	100	99
ACL	91	84	97	92	89	72	98	96	96	90
Patellar cartilage	73	86	80	85	40	21	94	99	79	85
Tibial cartilage	27	55	98	98	70	67	87	96	86	95
Femoral cartilage	65	44	94	96	77	83	90	81	88	81
Total	74	73	94	93	81	77	91	91	89	88

SS sensitivity; SP specificity; PPV positive predictive value; NPV negative predictive value; ACC accuracy. 1 = Reader 1; 2 = Reader 2. PCL = Posterior Cruciate Ligament; ACL = Anterior Cruciate Ligament

tion of osteo-ligamentous structures, articular surfaces and peri-articular knee tissues (1).

Arthroscopy, on the other side, is a highly sensitive and specific procedure for evaluating endocapsular structures (2-5) but invasive and no more accepted as sole diagnostic instrument.

As mentioned above, high-intensity field devices (>1T) allow for spatial and contrast resolution and a signal-to-noise ratio not obtainable with low-field equipment (<0.5T), if not increasing scanning time at the expense of increasing artifacts from movement (14,15).

Here we emphasize the use of low-field equipment dedicated to the joints, cheaper and more versatile than the large and expensive high-field equipment of proven diagnostic quality (4,16-20).

Our results are in line with literature as regards the evaluation of pathological findings on menisci (2,5,14,21) and cruciate ligaments (2,5,6,21-24) with a good (93% and 96% respectively) diagnostic accuracy and a good to excellent inter-observer concordance (Table 5).

Riel et al. (5) correctly identified, using the low field MR, the 3 lesions of the PCL present in their own study, as well as Lokannavar et al. (24) correctly identified two kind of lesions in their own study. Although our results were in line with these studies about the PCL injuries, it is still difficult to draw statistical conclusions with such small size samples.

The low diagnostic accuracy associated with the low inter-observer concordance found in detecting cartilage lesions reveals a weakness in diagnosing cartilage injuries by the 0.3T MR equipment. In our experience, the major discrepancies between radiological and arthroscopic findings are referred to grade I-II chondral injuries, mostly about patella (average error 24.5%), and less (15% and 14.5% respectively) for tibia and femur (trochlear cartilage) (Figure 6).

Scarcity of studies on articular surface evaluation by low-field MR makes it difficult to compare our data with literature. In particular Lee et al. (3) comparing their chondral lesions findings between low-field MRI and arthroscopy, obtained 8% of sensitivity and 94% of specificity, while Riel et al. (5) evaluating only grade III chondral lesions and comparing them with arthroscopy obtained 72% of sensitivity and 100% of specificity.

Best results in the field of chondral lesions are obtained with machines capable of developing more intense fields (> 1T); especially, the recent use of 3T equipment has allowed good diagnostic reliability also with 76% of sensitivity and 95% of specificity (16,18,19).

Conclusions

The present study confirms the reliability of the MR examination performed by low-field equipment for meniscal and ligamentous lesions, while demonstrates the limitations of the tool in detecting mild chondral lesions. Especially, the diagnostic accuracy of

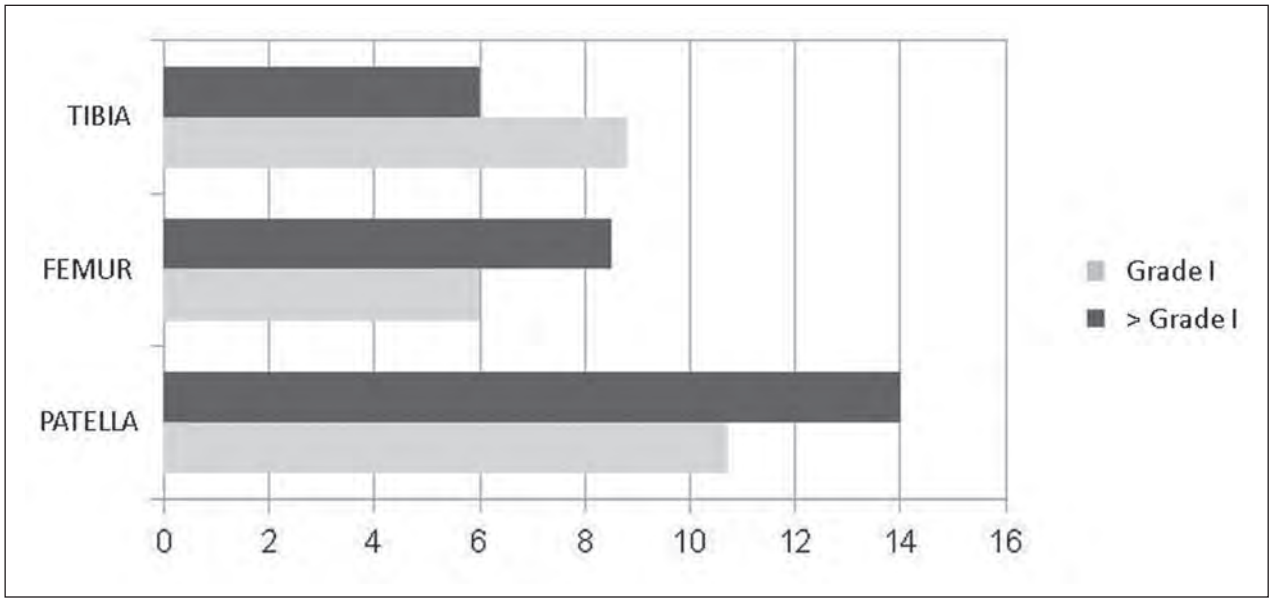

Figure 6. Visual representation of percentages of diagnostic errors for cartilage divided in degree I or degrees II-III-IV (according to the Outerbridge classification)

the latter is positively affected by the increase of the magnetic field of the latest MR equipment; however the low availability of the same and the highest cost of purchase and management makes their use not convenient except in selected cases.

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Original article

Do tourniquet and drainage influence fast track in total knee arthroplasty? Our results on 151 cases

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Summary. *Background:* Fast track in total knee replacement (TKR) is a widely used protocol. Tranexamic acid proved to be effective in reducing perioperative bleeding without increasing thromboembolic risk. The aim of this study was to assess if tourniquet and suction drainage might affect perioperative blood loss and post-operative functional recovery after TKR. *Methods:* 151 patients, who underwent to TKR, were assessed and divided into three homogeneous groups: group A (51 patients) in which both tourniquet and suction drainage have been applied (tourniquet has been release before wound closure); group B (50 patients) in which neither tourniquet nor suction drainage have been used; group C (50 patients) in which only tourniquet has been used. Perioperative intravenous tranexamic acid and post-operative low-molecular-weight heparin have been administered. Trend of haemoglobin values, transfusion rate, pain, ability to obtain 90 degrees of flexion and length of stay were analysed. *Results:* The average intra-operative blood loss was statistically higher in group B in comparison to other two groups. Haemoglobin values were lower in group A in comparison to group C in the third and fifth post-operative days. Patients in group A had higher transfusion rate, higher pain and had more difficulties in reaching a 90 degrees of knee flexion than the other two groups. There was one infection in group A. No differences in length of stay. *Conclusion:* Suction drain seems to be associated to lower haemoglobin values, higher transfusion rate, higher pain and slower functional recovery. Short-term tourniquet does not influence post-operative bleeding and rehabilitation program. (www.actabiomedica.it)

Key words: total knee replacement, blood loss, tourniquet, suction drainage, tranexamic acid

Background and aim of the work

Total knee arthroplasty (TKR) is one of the most common surgical operations in orthopaedics. Fast track protocol introduced in general surgery by Kehlet H. (1) is now applied in total hip and total knee replacement in several orthopaedic realities, aiming to improve the functional recovery of the patients without increasing complications, making easier the return to daily activities. Blood loss is particularly severe after TKR: a decrease of haemoglobin level from 2 to 4 g/dL is reported (2). So, with a view on fast track, blood loss management is important for avoiding cardiovascular complications related to anemia. In fact, the reported 30-day incidence of acute myocardial infarction after total hip replacement and TKR varies from 0.3% to 0.9% (3). Suction drains are routinely used in orthopaedics (4), because of the theoretical advantages of lower incidence of hematomas, wound complications, joint swelling, infections and, of improving rehabilitation, but their use is not justified by literature (5, 6). Some orthopaedic surgeons usually clamped the suction drain, but also this aspect is an age-old practice, not based on evidence (7). Intravenous and/or intra-articular tranexamic acid, acting as an inhibitor of plasminogen activation, reducing hyperfibrinolysis, has proved to be effective in reducing peri-operative bleeding in major orthopaedic surgery without increasing thromboembolic complications (8, 9). Finally the use of pneumatic tourniquet and the

timing of tourniquet release are controversial too (10, 11).

Given these premises, we wondered if these aspects could affect fast track protocol in our unit. Thus, the purpose of the present study was to assess the influence of closed suction drainage and tourniquet on peri-operative bleeding and functional recovery after total knee arthroplasty.

Methods

203 consecutive patients underwent to TKR from September 2016 to November 2018 in our unit (Orthopaedics and Trauma Unit – St. Polo's Hospital in Monfalcone, Italy). We excluded 52 patients because of coagulopathy disorders, anticoagulant and antiplatelet therapy (table 1: list of eligibility criteria). At the end we considered 151 patients that we divided in three homogenous groups based on usage of tourniquet and suction drainage: group A (51 patients – both tourniquet and suction drainage had been used), group B (50 patients – both tourniquet and suction drainage had not been used) and group C (50 patients – only tourniquet had been used). Characteristics of the groups are described in table 2. Tourniquet had been inflated for the whole surgical time at 300 mmHg and released before wound closure in groups A and C. Tourniquet had been inflated just for cementation phase in group B. Suction drainage had not been clamped and had been removed in the first post-operative day. All patients signed a proper informed consent form. Three different orthopaedic surgeons implanted the TKR using medial parapatellar approach, tibial extramedullary guide and femoral intramedullary guide after proper pre-operative planning. The type of implants used were Triathlon® (Stryker, Kalamazoo, USA) and Attune® (DePuy Synthes, Warsaw, USA). The same peri-operative fast track protocol had been applied in all three groups. Particularly, intravenous (iv) Cefazoline 2 g was administered 30 minutes before surgery. Two doses of intravenous tranexamic acid (15 mg/kg) were infused 20 minutes before surgery and after 4 hours. The antalgic therapy was periarticular infiltration with 60 mL of Ropivacaine 7.5%, Paracetamol 1 g iv every 8 hours and Oxycodone/Naloxone 10/5 mg 1 tablet every 12 hours. Thromboprophylaxis (Enoxaparine 4000 IU) started 12 hours after the operation. The knee was holded at 60-degrees of flexion for 4 hours, then the patients started continues passive motion for 30 minutes.

The haemoglobin values have been recorded in the pre-operative period, in the immediate post-op (T0),

Table 1. List of eligibility criteria

Inclusion criteria	Exclusion criteria
• Age between 50 to 85 years • ASA status ≤3 • Primary total knee replacement	• Contraindication to tranexamic acid • Antiplatelet or anticoagulant therapy • Coagulopathy disorders (i.e. hepatopathy, hemopathy…) • History of thromboembolism • Platelet count <150,000 mm3 • aPTT ratio and INR >1.20 • Serum creatinine >1.5 mg/dL

ASA status = American Society of Anesthesiologists

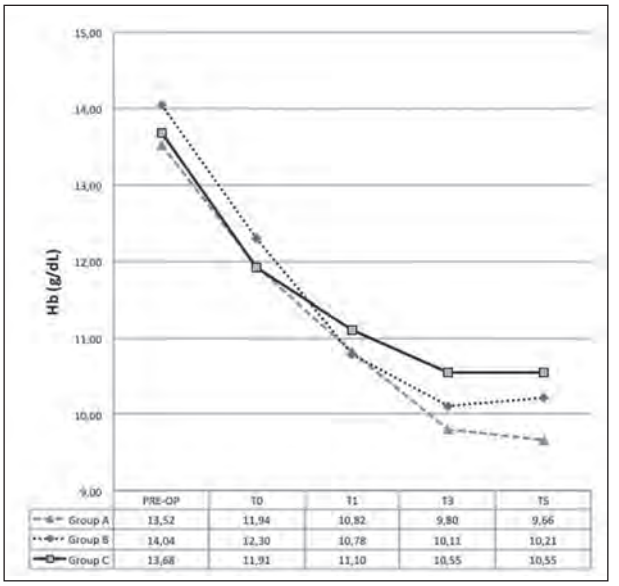
Table 2. Characteristics of the groups

	Group A (n=51)	Group B (n=50)	Group C (n=50)
Tourniquet applied	Yes	No	Yes
Suction drained applied	Yes	No	No
Tranexamic acid iv	Yes	Yes	Yes
Average age (years)	73 (51-83)	70 (53-81)	75 (58-85)
Sex (Female/male ratio)	1.7	2.2	1.5
Average ASA status	2.31	2.06	2.18

iv = intravenous

in the first, third and fifth post-operative days (T1, T3, T5 respectively). Intra-operative blood loss and percentage of blood transfusions have been measured in each group; blood loss in the suction drain at 24 hours has been recorded only for group A. All patients have also been clinically and functionally evaluated using the Numeric Rating Scale (NRS) at T0, T1 and T3, assessing the ability to reach a knee flexion of 90 degrees 6 hours after surgery, and recording the length of stay and possible haemorrhagic and thromboembolic complications.

Graph Pad Prism 6 and Microsoft Excel have been used for statistical analysis. All parameters have been compared in the three groups. Because the considerate variables had non-normal distribution, non parametric Mann-Whitney test (two-tailed) has been applied, considering a value as statistically significant if $p < 0.05$.



Graphic 1. Trend of haemoglobin values in the three groups: pre-operative, T0 (immediate post-op), T1 (the first post-op day), T3 (the third post-op day), T5 (the fifth post-op day)

Results

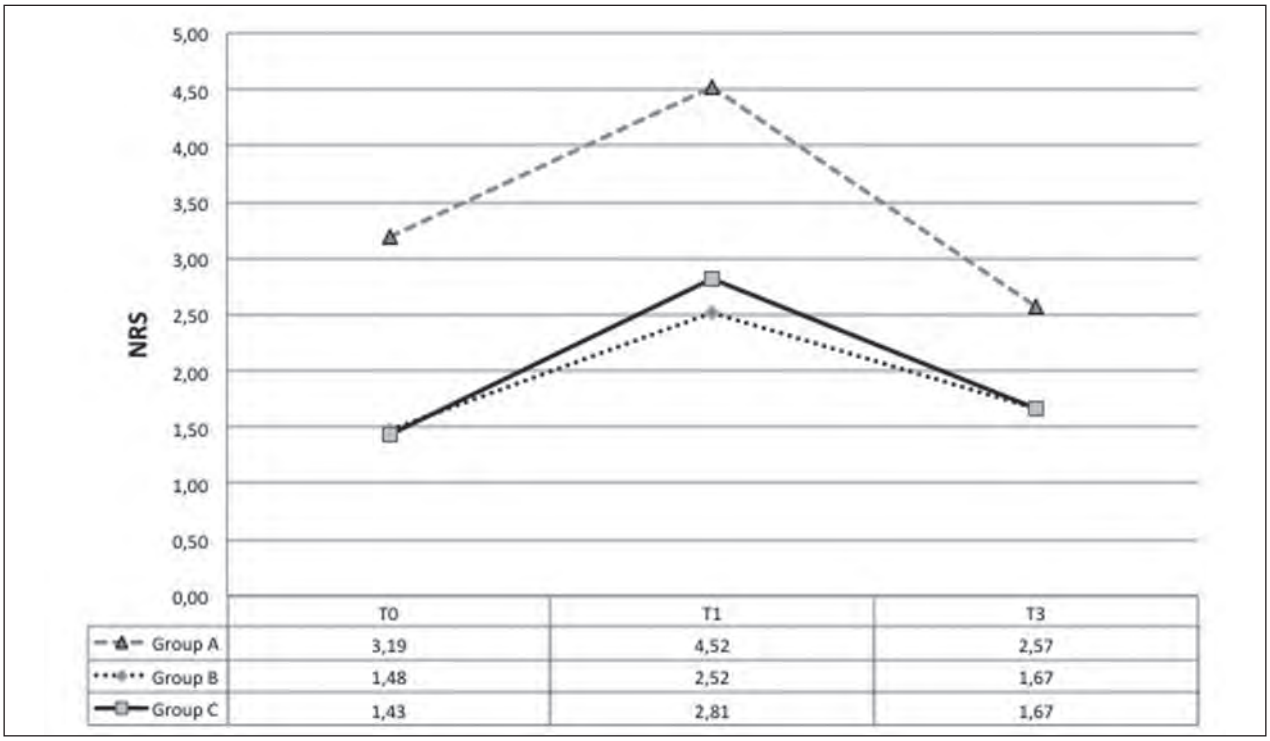
The trend of haemoglobin values and their differences in the three groups were described in graphic 1. Particularly, there was a statistically significant difference in T3 and T5 between group A and group C (T3: 9.80±1.35 g/dL versus 10.55±1.37 g/dL, p=0.049; T5: 9.66±1.36 g/dL versus 10.55±1.34 g/dL, p=0.024).

The average intra-operative blood loss was statistically higher without tourniquet inflation (group B) in comparison to group A and C (group B 607.14±171.13 mL versus group A 199.00±106.19 mL versus group C 168.42±101.67 mL, p <0.0001). The average blood loss in the suction drain in group A was 553±284 mL. As regards the blood transfusions, group A (in which suction drain had been inserted) had higher transfusion rate (group A 20.00% versus group B 2.86% versus group C 5.00%). The results are summarised in table 3.

Pain measured as NRS was higher in group A in comparison to the other two groups. The NRS values are described in graphic 2. Patients in group B and C were better in obtaining a 90 degrees of knee flexion at 6 hours after surgery (group B 92.5% versus group C 87.5% versus group A 62.5%, p<0.05). There were no statistically significant differences in terms of length of stay (group A 8.53 days versus group B 7.56 days versus group C 7.53 days). We had one early periprosthetic infection in group A; neither hematomas nor cardiovascular nor thromboembolic complications had been recorded in the other two groups.

Table 3. Results in the different groups. NA = not applicable

	Group A (n = 51)	Group B (n = 50)	Group C (n = 50)	
Blood loss:				
• intra-operative (mL)	199.00±106.19	607.14±171.13*	168.42±101.67	p<0.0001
• suction drain (mL)	553±284	NA	NA	
Transfusion rate	20.00%*	2.86%	5.00%	p<0.0001
Ability to 90 degrees	62.5%*	92.5%	87.5%	p<0.05
Lengh of stay (days)	8.53 (4-18)	7.56 (4-12)	7.53 (4-11)	p>0.05
Complications	1 infection	0	0	



	T0	T1	T3
Group A	3,19	4,52	2,57
Group B	1,48	2,52	1,67
Group C	1,43	2,81	1,67

Graphic 2. Trend of pain measured with NRS: T0 (immediate post-op), T1 (the first post-op day), T3 (the third post-op day)

Conclusions

Fast track protocol in TKR is widely used in all over the world. Several orthopaedics surgeons still use suction drain and/or tourniquet, although their use is not supported by scientific data, but it is related to our beliefs and routine behaviours (4, 6, 12). Thus in the present study we wondered if these practice could influence blood loss and functional recovery after TKR.

Doubts regarding the usefulness of the suction drain had been reported in the late 1980's, when Reilly TJ et al. (13) reported more than twice blood transfusions given to the patients whose knees were drained with a greater decrease in haemoglobin level than the non-drained group. Hematoma is always a complication feared by orthopaedic surgeons. In fact it can be colonized by bacteria and it can swell the joint and increase the pain, creating discomfort to the patient and delaying his/her rehabilitation. Although correlation between suction drainage and periprosthetic infections is not supported (5-7), this is described in different animal study (14, 15) and also in some clinical studies in general surgery (16, 17), because suction drain might be an entryway for bacteria. Sorensen AI et al. (18) reported positive drain tip cultures and an increased risk of infection only when the drain removal occurred after 6 days. In our study we had one early infection in the group in which suction drain had been used.

Even if Lee QJ et al. reported better clinical results inserting the drainage (19), in the literature the absence of drainage is not associated to increased amount of hematomas and periprosthetic infections (2, 12), but to a higher need for transfusions (2, 30). In the present study use of suction drainage was associated to a greater decrease in haemoglobin level and to a higher transfusion rate (20% versus <5%). In the literature blood transfusions after TKR are reported up to 50% of TKR in the different case series (2). Transfused patients can develop immunological, infectious, cardiovascular complications and death (20), so guidelines and protocols for describing the proper use of blood products are applied in every hospital (21, 22). The bleeding control in the perioperative time is fundamental for reducing blood transfusions and their

potential risks and for avoiding complications related to anemia. Especially in a fast track protocol, different strategies are applied. Proper surgical technique, particularly addressed to soft tissue sparing, use of electrocautery, compressive dressing, post-operative knee flexion, cryotherapy (23), tranexamic acid, clamping of the suction drain when applied (24, 25), are treatment that can improve the bleeding (22, 26). Intravenous and/or topical tranexamic acid is commonly used in orthopaedic surgery and its effectiveness is widely demonstrated without increasing thromboembolic complications (8, 9, 27). In fact tranexamic acid acts against fibrinolysis that in surgical patients is pretty high and it is associated to high mortality rate (28). Clamping the suction drainage for few hours after surgery might help in reducing blood loss and requirement for blood transfusion (24), creating a tamponade effect, but the usefulness of this practice and the duration of drain clamping are debated in the literature (25).

Blood transfusions are associated to longer length of stay in hospital, delayed rehabilitation programs and increased costs (29, 30). Bierbaum BE et al. reported up to a 20% increase in hospital costs and a 20 to 25% increase in the length hospitalization in transfused patients (26). Different studies showed that better blood management is associated to cost reduction. Mehra T et al. observed that reduction in the blood transfusions by 27% allowed saving more than 2 million USD in a year (31).

Routine use of tourniquet in TKR is another point of discussion. It allows a better view for the surgeon creating a bloodless surgical field and it seems to reduce intra-operative bleeding, but these aspects are not supported by scientific studies (32). Also its role in cementing technique could be just theoretical (33). In the present study there were no differences in haemoglobin levels drop down and in transfusion rate using or not the tourniquet. Even if tourniquet is described as one of the most important risks for thromboembolism (32) and associated to several complications (34-36), in the present study tourniquet was not associated to higher complication rate, particularly neurovascular deficit, skin necrosis, thromboembolic events and difficulties in quadriceps recruitment. In fact tourniquet can be safely applied following some simple recommendations to avoid ischemia-reperfusion injury, and limiting its long duration use (36, 37). Dennis DA et al. (38) reported reduced quadriceps strength during the first 3 months after TKR and lower intra-operative blood loss when tourniquet had been used. Even if reduction of quadriceps electromyographic signal has been described at the first post-operative period, it is not shown the initial quadriceps damage leads to long-term muscular atrophy and weakness (39). In fact the presence of lot of confounding factors should be considered. Different inflation timing and period, different inflation pressure and pre-operative muscular conditions might prevent proper comparisons. In the present study tourniquet has not been associated to late functional recovery, to prolonged length of stay and to higher pain level, but a correlation with the use of drainage has been observed. In fact patients with drainage had worse pain (this difference remained statistically significant not only in the immediate post-operative time, but also in the first and third post-operative days) and less ability to flex the knee. Only clinical quadriceps recruitment and not a leg-raise test had been evaluated.

Finally the timing of tourniquet release during TKR is also controversial. Tourniquet can be release either before or after wound closure. According to different Authors, both might bring to some advantages and influence perioperative bleeding in different ways. Early release should allow better identification of vascular injuries, reducing post-operative complications and improving patellar tracking assessment (10, 40), instead late release preceded by compressive dressing should reduce surgical time and limit the bleeding creating a tamponade effect (41). Actually, review and meta-analysis did not confirm these aspects (5, 42). Rama KR et al. (11) described higher total blood loss in early tourniquet release even if there was a higher early re-operation rate in late tourniquet release (0.3% versus 3.1%). In our study we did not analysed this aspect, because tourniquet had always been released before wound closure.

The present study has some limits. It is not a prospective randomized control study. The groups are made of small number of patients. Patients in each group had been operated for the most part by the same surgeon; so surgical technique and expertise of the single surgeon might have influenced bleeding. Blood loss

in each group has been measured and not calculated (for example with Gross's method, 43). In literature measured total blood loss is often underestimated compared to calculated blood loss (44).

In a fast track protocol for TKR not to use the suction drainage should become common practice, even if the decision should be personalized on patient's risks factors. Avoiding the drainage in association of other elements of blood management, like tranexamic acid, might help in reducing the blood transfusion rate, improving patient's functional recovery, reducing not only the costs related to length of stay and patient's management, but also the social costs. As regards the decision to use or not to use the tourniquet, even if intra-operative blood loss might be reduced, there is no agreement about reduction of total blood loss. Thus the literature does not prove against its use, as long as surgical time is short, rehabilitation program starts early and patient's thromboembolic risks factors are identified.

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Original article

Intramedullary nailing through a suprapatellar approach. Evaluation of clinical outcome after removal of the device using the infrapatellar approach

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Summary. *Background and aim of the work:* Since 2006, It has been developed the possibility to introduce a tibia nail through a suprapatellar access. However, the removal of device must be carried out using the classic infrapatellar approach. The aim of this study is to evaluate the clinical scores of a group of patients that removed a tibial nail by infrapatellar approach, previously introduced through a suprapatellar access. *Methods:* Seven patients received removal, through infrapatellar access, of tibial nail previously introduced by suprapatellar approach. Despite being VAS <5, patients requested the device to be removed. The variables studied were the distance between the apex of the nail and the tibial plateau (TPD) and between the apex of the nail and the anterior tibia (ATD), oxford knee score (OKS), Kujala score (KJS), Visual Analog Scale (VAS) and SF 36 before surgery and 1 year. A1 year of follow up the Sidky-Buckley questionnaire was administered. The follow-up was 1 year. *Results:* The mean VAS was 2.8 before surgery and 0.5 at 1 year after surgery, OKS average pre-surgery is 38 (good), while at 1 year it becomes 44 (excellent). The Sidky-Buckley questionnaire showed that all patients would have the intramedullary nail removed again. The widest improvement in all parameters is seen in the two patients with less distance from the tibial plateau. *Conclusions:* Although the patients had received initial suprapatellar access and a second infrapatellar for the removal of the device, no complications were reported regarding the use of the two accesses. (www.actabiomedica.it)

Key words: removal tibial nail, suprapatellar approach, removal using the infrapatellar approach

Introduction

The infrapatellar approach for the nail insertion has long been considered the standard procedure, however high incidence of anterior knee pain (1), ranging from 10 to 80% (2,3), has been reported. Thus in 1996 Tornetta and Collins (4) developed a semi extended nailing technique who employed a medial parapatellar approach with lateral subluxation of the patella, and since 2006 the suprapatellar approach for extended knee tibial nailing has gained popularity (5). Several recent studies compare suprapatellar and infrapatellar approaches for intramedullary tibial nail showing that suprapatellar nailing has advantages over infrapatellar nailing (6-9). Those advantages are even more evident when related to specific indications, such as proximal third of tibia (10).

Techniques in nail removal might be another aspect to study when comparing infrapatellar and suprapatellar approaches as around 30% of patients with

intramedullary tibial nail asks for removal (11). Indications for the removal of internal fixation may include knee pain, infection, or patient preference (12).

Nails introduced with an infrapatellar access could be removed trough the same access, whereas it is necessary to use a different access (infrapatellar) for the device removal when a suprapatellar approach has been used.

To our knowledge no study evaluates patients who underwent removal of a suprapatellar tibial nail through an infrapatellar approach, although some studies in literature analyze results of removal of nail inserted via infrapatellar access (13, 14).

The aim of this study is to evaluate the clinical scores of a group of patients that removed a tibial nail by infrapatellar approach, previously introduced through a suprapatellar access.

Patients and methods

From November 2015 to December 2016, seven patients that received removal through infrapatellar access, of the tibia nail previously introduced by suprapatellar approach were enrolled in our study.

Inclusion criteria were: tibial or tibiofibular fracture treated with intramedullary nail introduced through the suprapatellar approach and removed via infrapatellar access; healing of the fracture; age over 18 years and under 60 years old; decision of the patient to remove the nail even if VAS (Visual Analog Scale) score before surgery was <5. This last criterion was insert in order to better understand if the use of two access, the suprapatellar and the infrapatellar, could lead to complications. Exclusion criteria were: pathological fracture; ipsilateral femur fracture; previous knee surgery; presence of early osteoarthritis.

All patients underwent surgical procedure for the removal of the implant by the same surgeon (MM). They were placed in the supine position and received a regional anesthesia.

All locking screws except one of the proximal locking screws were removed, then screw the extraction screw into the nail and tighten it to prevent rotation or displacement of the nail posteriorly below the tibial plateau. For the exposition of the nail apex, the incision starts proximally at the distal third of the patella along the patellar ligament, and a transpatellar approach was used. Intravenous administration of tranexamic acid and elastic bandage ware routinely used. No drainage was used in the post-operative. Patients were encouraged to flex and extend the knee immediately after surgery. Partial weight-bearing was given for 1 week and then a complete weight-bearing was given.

The clinical variables studied were oxford knee score (OKS), Kujala score (KJS), Visual Analog Scale (VAS), SF 36 before surgery and 1 year. The radiological variables were the tibial plateau distance (TPD) that is the distance between the apex of the nail and the tibial plateau and the anterior tibial distance (ATD) that is the distance from the apex of the nail and the anterior tibial profile (Fig. 1). At 1 year of follow up the Sidky-Buckley questionnaire was administered (13). The minimum follow-up was 1 year. Data were recorded by two independent orthopedic surgeons (GN and CF), and the value reported in table 1 and 2 were the average of the two measurements.

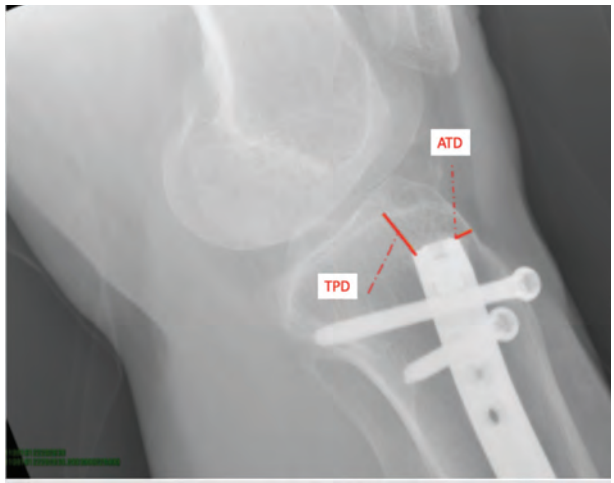

Figure 1. Pre-operative X-Ray that shows the tibial plateau distance (TPD) that is the distance between the apex of the nail and the tibial plateau and the anterior tibial distance (ATD) that is the distance from the apex of the nail and the anterior tibial profile

Table 1

	Sex	Age	VAS pre-op	VAS 1 year FU	rifarebbe	Kujala pre-op	Kujala 1 year FU	OKS Pre-op	OKS 1 year FU	DP	DT
BMC	F	43	2	2	2	70	92	31	40	13,06	7,12
MI	F	61	3	0	2	96	98	43	48	10,95	6,70
GE	M	39	4	0	2	70	88	35	47	3,99	13,43
DDA	M	54	2	0	2	93	97	46	47	12,59	6,49
RD	M	55	2	0	2	80	90	36	44	11,07	7,66
BR	F	44	2	1	2	94	97	44	48	12,34	8,90
BE	M	40	4	0	2	67	90	37	40	2,99	12,47
Average											

Table 2

	PF PRE-OP	PF 1 Y FU	P PRE-OP	P 1 Y FU	HP PRE-OP	HP 1 Y FU	CH PRE-OP	CH 1 Y FU	EV PRE-OP	EV 1 Y FU	MH PRE-OP	MH 1 Y FU	SC PRE-OP	SC 1 Y FU
BMC	55	80	67	89	55	60	50	75	75	75	84	84	78	89
MI	75	80	56	89	65	65	25	75	85	90	80	96	89	89
GE	55	90	65	90	53	70	50	75	75	75	80	84	78	90
DDA	80	80	89	100	65	65	50	50	75	80	96	96	78	89
RD	82	83	90	100	65	70	45	50	75	85	94	96	82	89
BR	60	75	70	89	55	60	50	70	70	75	82	84	80	88
BE	54	88	60	90	53	75	50	75	70	75	83	86	76	88
Average														

SF-36 COMPONENT LEGEND

Physical Function (PF)
Pain (P)
Health perceptions (HP)
Change in health (CiH)
Energy / Vitality (EV)
Mental Health (MH)
Social Function (SC)

Results

We enrolled 7 patients (3 females and 4 males). The median age was 49 years. (range 39-55).

There were five cases of tibial fractures alone and two cases of tibiofibular fractures, of which one AO 41-A1, one AO 43-A1, two AO 42-A1, one AO 42-A2, one AO 42-A1, one AO 42-C2 and two cases of fibular fracture AO-4F3A (Muller Arbeitsgemeinschaft fur Osteosynthesefragen).

The fibular fractures were treated using osteosynthesis with plate which were removed together with the nail.

All wounds healed and no post-operative infection or fracture occurred after the removal of the nail. The mean VAS score was 2.8 before surgery and 0.5 at 1 year after surgery. The mean KJS pre-surgery was 81 and 93 post-surgery, OKS average pre-surgery is 38 (good), while at 1 year it becomes 44 (excellent) (Fig. 2, 3). The mean TPD was 11.43 (two patients with TPD <4), whereas the mean ATD distance was 8.96. Considering SF 36 there is an improvement in the parameters of physical health, passing from an average physical activity of 66 to 82 to a year and from 71 to 92 in the pain parameter. The general health parameter also goes from an average of 49 to 66. From the Sidky-Buckley questionnaire it was found that all patients would have the intramedullary nail removed (13). The widest improvement in all parameters is seen in the two patients with the less distance from the tip of the nail to the tibial plateau. This result confirms the results of Zhang et all. and give a great importance to the nail length in order to sink the nail and to reduce the tibial plateau distance (TPD) (14, 15).

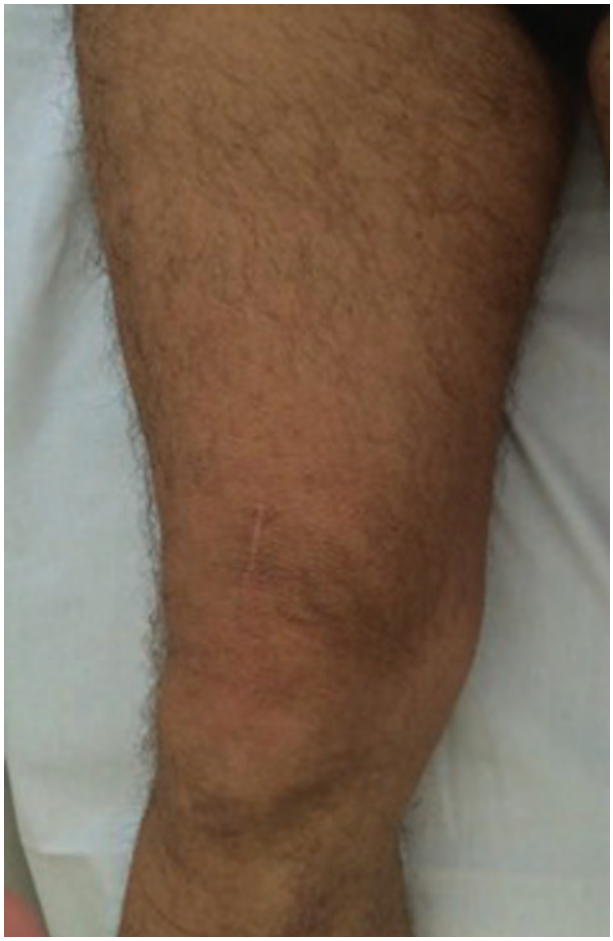

Figure 2. Range of motion at 1 year after the remove of the device

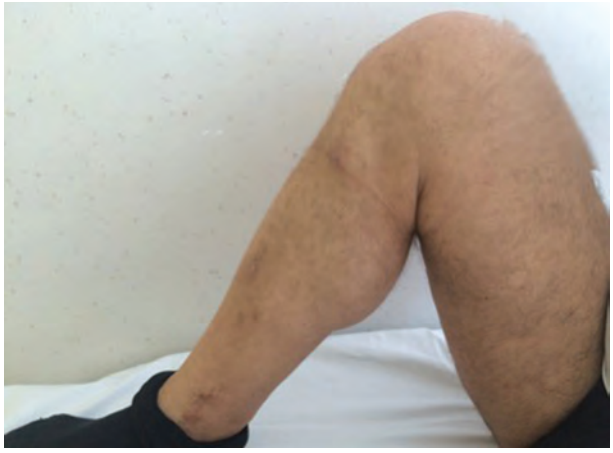

Figure 3. Range of motion at 1 year after the remove of the device

Discussion

Suprapatellar technique for intramedullary tibial nailing is becoming more popular over the years. The semi-extended position for intramedullary nailing of the tibia is particularly useful when treating difficult metaphyseal and metadiaphyseal proximal tibia fractures (4), as obtaining an acceptable reduction is very difficult in traditional infrapatellar approach due to the muscle forces that act on the fracture site. The fracture of the proximal third of the tibia, in fact, result in a varus deformity due to the quadriceps muscle and gastrocnemius muscle. Moreover, this tibial segment is difficult to visualize when the tibia is more than 40cm long, because the image intensifier impinges on the entry wire (10). It is reported 58% of malreduction in tibial fracture of the proximal third after an infrapatellar tibial nail (16). The semi-extended position has a role as a useful technique in polytrauma patients for several reasons. It facilitates the positioning of the C-Arm, thus reducing the intraoperative fluoroscopy time (5), avoid flexion or hyperflexion of the knee (e.g. in patient with pelvis fractures) (17).

In the literature, several studies have compared suprapatellar versus infra-patellar approach for tibia intramedullary nailing showing that suprapatellar approach led to a significant shorter fluoroscopy time and better sagittal plane alignment and lower incidence of angular malalignment without increasing risk of postoperative complications (7, 18).

The first concern reported is that suprapatellar approach might damage the patello-femoral joint during nail insertion as well as others intra-articular structures due to inability to achieve an accurate entry point for nail insertion. Reviewing the literature there are in vivo and cadaveric studies showed no chondral damages when suprapatellar approach is used (6, 19). Moreover, modern instrumentation used a specific cannula system to reduce the risk of iatrogenic damage to the surrounding articular cartilage, allowing safe nail insertion (17). Gelbke's cadaveric study quantified the peak pressures within the patella-femoral joint, comparing suprapatellar and infrapatellar approach, showing that for both techniques, the peak pressures were below the thresholds that have been reported to be detrimental to the joint cartilage (20). However,

even when signs of chondral damage are present, patients are rarely symptomatic (6).

A second concern regarding suprapatellar approach is the necessity of a different entry point for the eventual removal of the nail. To our knowledge no studies have been made to analyze the outcome of infrapatellar removal of a suprapatellar inserted nail. Also, regarding removal of infrapatellar inserted nail only a very few articles have analyzed outcomes, so indications for removing the device remain discussed (13, 14). Sidky et all analyzed 130 patients (134 fractures) that removed their implant, showing that 72,2% of patients had an improvement in their symptoms and surprisingly they showed as sex (female) and litigation are positive predictive factors for patient requests to have tibial nail removed (13). The study conducted by Zhang et all. for the first time managed to give us radiological bases for the removal of the nail. In fact, patients with a short distance from the tip of the nail tail to the tibial plateau (<10 mm) and to the anterior border of the tibia (<6 mm) has a VAS score ≥ 4 and relieved pain significantly after the removal of the nail (14).

The limitations of the present study are the absence of a control group, and the small sample size. Strengths of the study are the use of multiple subjective and objective functional scores, and most of all it is the first study in the literature analyzing infrapatellar removal of suprapatellar inserted tibial nail.

Conclusions

Although a small number of patients, our study reports no complications regarding the use of the two accesses, in patients that received initial suprapatellar access and a second infrapatellar for the removal of the device. However, the removal through infrapatellar access, of a tibial nail, previously introduced with suprapatellar access, has shown good clinical results. An improvement in the physical and mental health and an improvement in the clinical scores was observed. The two patients with less distance from the tip of the nail to the tibial plateau had the highest improvement in all parameters as demonstrated by Zhang et all (14).

The work was done at the department of Orthopaedics Traumatology and Spine surgery, Catholic University, "A. Gemelli" University Hospital, Largo A. Gemelli 8, 00168, Rome, RM, Italy.

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Original article

Preliminary experience in the arthroscopically assisted treatment of tibial plateau fractures

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Summary. *Background and aim of the study:* Fractures involving the tibial plateau make up 1% of all fractures. Treatment can take advantage of various techniques, including arthroscopically assisted surgical reduction. This procedure is certainly viable for Schatzker III fractures and, in some cases, for Schatzker II. The use of the arthroscope makes possible a smooth reduction of the fractured bone, decreasing the risk of post-traumatic osteoarthritis, and also allows to diagnose and, if necessary, also treat the associated intra-articular lesions, which often are not highlighted during the classical preoperative investigations. *Methods:* In the last year we have operated with this technique 8 of the 22 cases of fracture of the tibial plate that have come to our emergency Department. Using the Schaztker classification, we performed an arthroscopically assisted reduction to treat type II and III fractures. The surgical operations involved a first arthroscopic phase, to assess intrarticular damage (bone, cartilage, ACL, PCL, menisci), a second phase for possible treatment of intrarticular lesions and reduction of fractures under arthroscope or open osteosinthesis. Finally, a last arthroscopic check was performed. *Results:* We obtained excellent results, as we were able to always have a fracture reduction of less than 1 mm, while clinically all the patients could have an early and almost complete functional recovery after only 2 months. *Conclusion:* The arthroscopically assisted technique could be an effective way to adress the anatomical reduction of tibial plate fractures, but must only be used in the indicated cases. (www.actabiomedica.it)

Key words: tibial plate fracture, arthroscopically assisted reduction, Schatzker classification, fracture reduction

Introduction

Tibial plateau fractures are not particularly frequent and constitute about 1% of all fractures (1). Often they involve sports subjects, as they are more exposed to high-energy trauma (2). In elderly people, however, the incidence of this lesion rises to 8% and is usually linked to low-intensity traumas, which act on a weaker bone (3, 4).

In most cases, the traumatic mechanism leading to this type of fractures provides for an important distortive trauma in which there is a combination of valgus and compression forces, which cause the impact of the lateral femoral condyle on the lateral tibial plate, causing a fracture with the sinking of the bone fragment. Less frequently, this injury can be caused by varus and compression trauma (2, 3, 5). There may then be factors that increase the chance of having these injuries, such as advanced age, osteoporosis and other comorbidities (3, 6). In these cases, even the compression force alone may be sufficient to cause a tibial plateau fracture (3).

The main classifications of tibial plate fractures are the one proposed by the AO and the one described by Schatzker (7-9).

The classification of the AO foresees 3 main groups of fractures:

Type A: extra-articular fractures;

Type B: partially articulated fractures, further divided into B1 (pure split), B2 (pure depression) and B3 (split-depression);

Type C: articular fractures, further divided into C1 (simple articulations, simple metaphyseal), C2 (simple articulations, multifragmentary metaphyseal) and C3 (multifragmentary articulations).

In the Schatzker classification, however, the fractures are grouped into 6 categories based on number and type of fragments resulting from the trauma. The first 3 types typically concern low energy trauma, while the others usually derive from high energy traumas:

I) Split fracture of the lateral condyle: resulting from a valgus trauma with axial force; typically in young subjects in which, thanks to the presence of a more resistant cancellous bone, there is only a fracture, without the compression of the fragment.

II) Split-compression fracture of the lateral condyle: in which the same type of trauma, however applied to a bone affected by osteoporosis, also produces the crushing of the articular surface with the sinking of the cartilaginous component inside the cancellous bone.

III) Pure compression fracture of the lateral condyle: here the force mainly involved is the axial one, which creates a pure sinking of the articular surface.

IV) Fracture of the medial plateau: resulting from varus traumas with axial force; fragment compression may also be present.

V) Fracture of both condyles: axial force acting on a fully extended knee; fragment compression may also be present.

VI) Complex bicondylar fracture with diaphyseal extension: high energy trauma causing a complex fracture in which the two tibial plates are separated by the diaphysis.

The main indication for arthroscopic assistance for the treatment of fractures is for type III ones according to the classification of Schatzker (5), but it is also possible to use it for type II fractures, provided that there is no excessive opening of the cortical bone.

The use of the arthroscopic assisted reduction technique for other fractures is inadvisable, as there is the risk of dealing with compartment syndrome (3, 5). Furthermore, for type II fractures with a breached cortical surface, if we want to use this technique for reduction, we need to work with low pressures in the arthroscope.

The aim of the study is to evaluate if arthroscopy can be a valid solution in the treatment of some tibial plateau fractures.

Materials And Methods

In the year 2017, 22 tibial plate fractures came to our attention, at the Orthopedics and Traumatology Department of Piacenza (Italy). The patients were males in 68% cases (15) and females in 32% (7). The patient's age at the time of surgery ranged from 36 to 69 years, with an average of 47.4 years. The average weight at the time of the operation was 78.4 Kg. From the radiographic images and, for some cases, also from CT images, we could divide them according to the Schatzker classification and were 2 type I fractures, 5 type II fractures, 3 type III fractures, 4 type IV fractures, 2 type V fractures and 6 type VI fractures.

We treated with arthroscopic assistance all type III fractures and also all type II fractures, because we had not cases with large cortical involvement, reaching a total of 8 cases (Fig. 1). Of these, 6 cases involved male patients and 2 female patients, with an age at the time of the operation between 36 and 53 years, and an average of 44.2 years. The average weight at the time of the operation was 84.6 Kg.

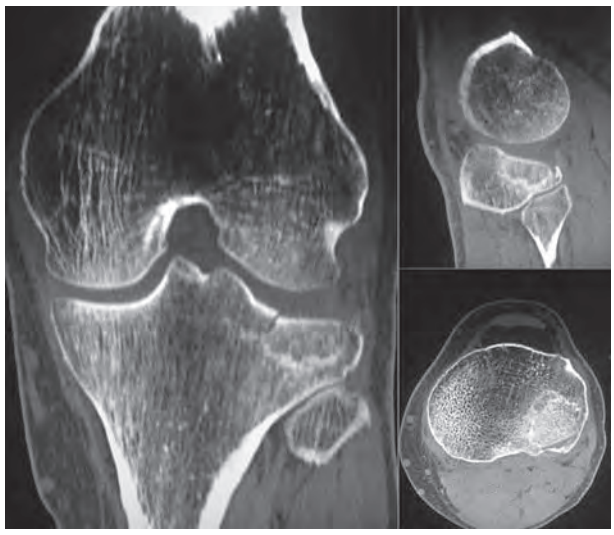

Figure 1. Pre-operative CT scan

For the surgery, we placed all the patients in supine decubitus on an operating table. A circumferential leg holder was applied to support the traumatized leg's thigh, allowing the surgeon to freely move the limb, both in flexion-extension and varus-valgus movements. A pneumatic tourniquet was placed at the proximal part of the thigh, which was inflated at the beginning of the surgery. The contralateral limb was held in the flexion-abduction position, while a c-arm was placed on the side of the patient. Distally to the tourniquet, a sterile field was set up. Through a standard two portals arthroscopy (anterolateral and anteromedial) it was possible to drain the hematoma and to wash the intra-articular cavity, after which, always through arthroscopy, we could clearly analyze the fracture and also check the state of the other joint structures (Fig. 2). If no other lesions were found, we can carry on with the tibial plate fracture treatment. Otherwise, the surgeon could possibly treat the concurrent intra-articular lesions (especially the meniscal lesions), before proceeding with the treatment of the fracture. In 2 cases we performed external meniscal suture.

The fracture was then arthroscopically analyzed. We proceeded by restoring the articular surface, using an tool to lift up the sunken bone fragment (Fig. 3) and through the arthroscope we looked at the reduction. Once we saw that the fragment had returned to the original anatomical position (Fig. 4), a synthetic bone graft was used to fill the gap that had formed.

Then, we passed to percutaneous or open osteosynthesis. In 3 cases we used the percutaneous treatment, inserting two cannulated screws of 7.3 mm; in 5 cases, instead, we did an open surgery with inserting a plate through a hockey stick incision, which was then fixed with screws.

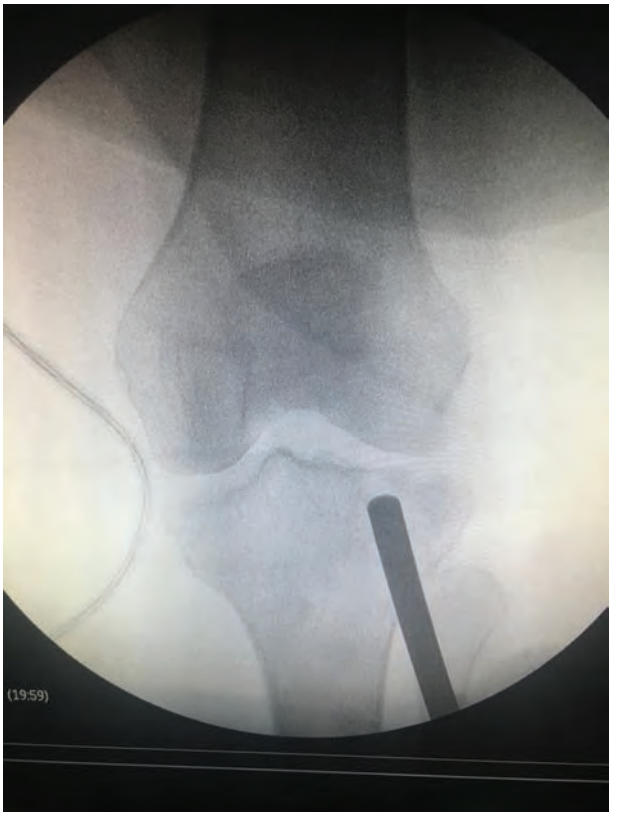

Figure 3. Intraoperative image of the tibial plate fracture's reduction

At the end of the synthesis, after the last check with the c-arm, an additional arthroscopy was performed to verify the correct restoration of the tibial anatomy. Then, we moved on to the final phase, with the removal of the tourniquet, the profuse washing of

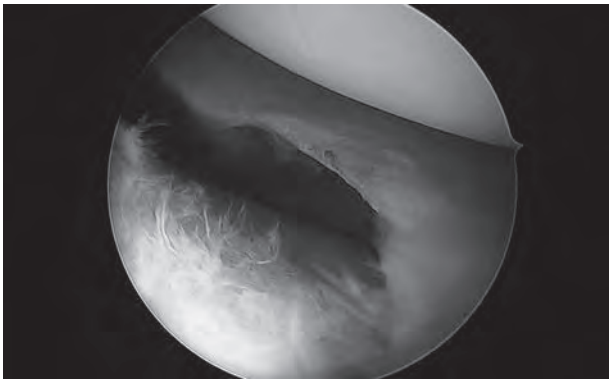

Figure 2. Arthroscopic view of the tibial plate fracture

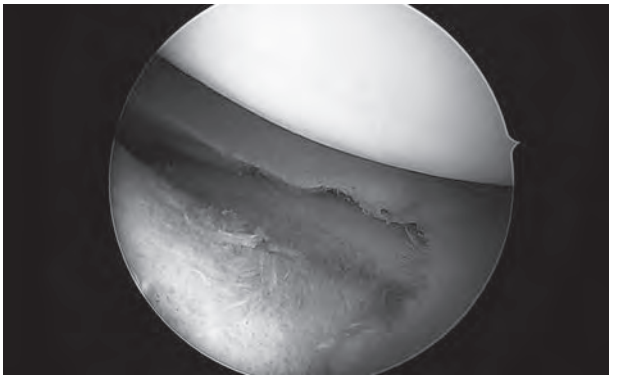

Figure 4. Arthroscopic result of the reduction

the joint cavity, the insertion of a drainage, the skin suture and, finally, the dressing.

The post-operative period was characterized by an early mobilization with flexion-extension exercises, to avoid the excessive stiffness of the joint. The load was not permitted for the first 4 weeks, after which an overflowing load was allowed in the next 3 weeks, and finally, the total load was progressively recovered.

During the resumption of the load, a DonJoy type brace could be used to avoid varus-valgus stress.

Results

The results achieved through arthroscopically assisted reduction were very good, both from the anatomical and clinical point of view. The arthroscopic view allowed us to evaluate the quality of the reduction in direct vision, which is not possible in the other treatments, and we could verify that we have obtained smooth anatomical reductions of less than 1 mm in all 8 cases treated, a result that is very difficult to achieve and check with other techniques. Moreover, thanks also to the rehabilitation protocol we have used, the excellent quality of the anatomical reduction obtained in the operating room has remained good over time, as demonstrated by the radiographic checks during the follow-up (Fig. 5).

Clinically, on the other hand, all 8 patients respected the rehabilitation time, and after 12 months from the surgery they all managed to obtain a flexion of at least 130 ° without pain (Fig. 6). But the most important thing is that after only 2 months the functional recovery was already almost complete, witnessing that, actually, the quality of the reduction is related to the clinical result.

At one year after surgery, during the control visit, all patients operated for tibial plate fracture were evaluated with the Knee Society Score (Table 1). We stratified the results obtained according to the category of fracture, and it was found that, for both the Knee score and the Funtion score, the highest scores were obtained from patients with type III fractures (total score 96), type II (total score 95) and type I (total score 93). Lower scores, however, were recorded by patients with type IV fractures (total score 90.5), type V (total score 87) and type VI (total score 84.5)

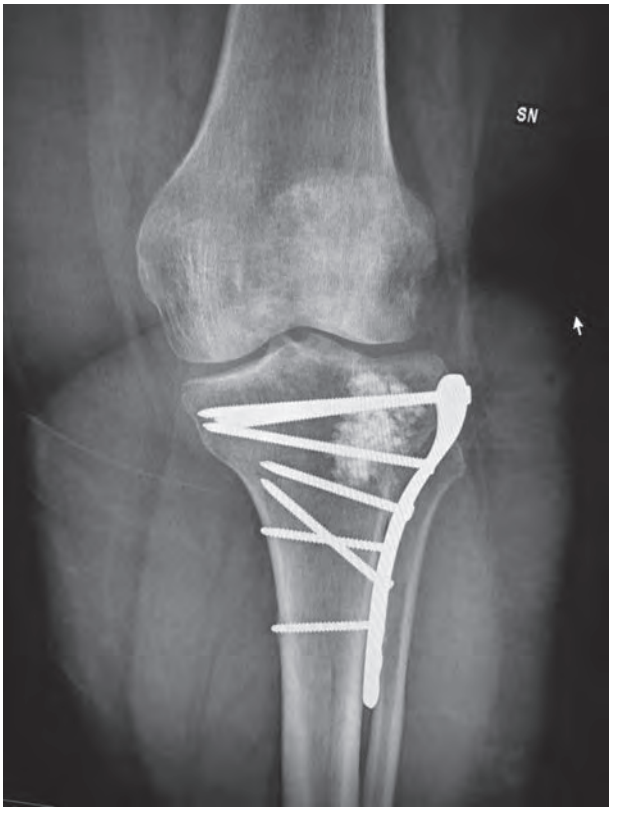

Figure 5. Post-operative radiography at 2 months

Figure 6. Post-operative result at 2 months. 120° flexion

Discussion

In the treatment of tibial plate fractures, two problems can arise: post-traumatic osteoarthritis and the non-diagnosis of co-occurring intra-articular lesions (2).

Table 1. Knee Society Score, 1 year after surgery

SCHATZKER CLASSIFICATION	KNEE SCORE	FUNCTION SCORE	TOTAL
I	90,0	96,0	93,0
II	92,0	98,0	95,0
III	94,0	98,0	96,0
IV	89,0	92,0	90,5
V	86,0	88,0	87,0
VI	82,0	87,0	84,5

Post-traumatic arthritis depends essentially on the quality of the reduction, consequently only being very accurate in the anatomical reconstruction of the joint we have the possibility to decrease the risk of incurring this long-term complication. Especially in Schatzker fractures type II and type III, the main problem that the surgeon must face is the collapse of the injured fragment that can cause a deformity of the articular surface and cause an altered mechanical functioning. Consequently, if the correct anatomy of the tibial plate is not restored, filling the empty space resulting from the compaction of the bone fragment, the joint will not be able to return to its normal status. The goal that the surgeon must pursue is that of a smooth anatomical reduction (2) of less than one millimetre and in any case not more than 2 millimetres.

The non-diagnosis of co-occurring intra-articular lesions derives from the fact that often a Magnetic Resonance Imaging to study meniscus, ligaments and capsule is not performed, and open surgery does not allow the precise diagnosis of these injuries nor even less their repair.

Arthroscopy can solve both these problems because the main advantages of its use are related to the possibility of optimally restore the anatomy of the tibial plateau, clearly see the intra-articular lesions and repairing them (3, 10). In addition, arthroscopic assisted reduction guarantees lower invasiveness than the ORIF (open reduction internal fixation) technique (2). A possible evolution of the technique could involve the use of a kyphoplasty balloon to lift the bone fragment that was sunk and also to firmly support it with the injection of an osteoconductive material (tricalcium phosphate), a synthetic bone or cement. This technique, which we have recently tested, allows us to be even less invasive and not to resort to large incisions, even if we want to wait for longer follow-ups before making final judgments.

Conclusion

Our clinical experience suggests that the arthroscopically assisted technique could be an effective way to adress the anatomical reduction of tibial plate fractures, allowing us to perfectly restore the patient's anatomy with an optimal clinical outcome, avoiding both the risk of post-traumatic arthrosis and of excessive joint stiffness. This technique, therefore, offers significant advantages compared to the ORIF, but must only be used in the indicated cases.

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Original article

Hemi-Castaing ligamentoplasty for the surgical treatment of chronic lateral ankle instability in young athletes: our 7 years experience

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Summary. *Background and aim of the work:* in this study we report our 7-years experience (from January 2011 to December 2017) of 35 patients with chronic lateral ankle instability treated with the Hemi-Castaing reconstruction procedure, all performed in our clinic. *Methods:* thirty-five patients (F12-M23; median age around 31 yrs, range 18-52 yrs). All patients used to practice amateur sports at competitive level. The procedures were performed in 19 cases on the right ankle whereas in 16 cases on the left ankle. The average follow-up was 54.2 months. *Results:* of the 35 patients included in our study, all of them were able to practice sport as the same level as before from 80 to 100 days after intervention. Optimal functional results were achieved in all patients and no further episodes of ankle sprain occurred. All patients rated their outcome as good/excellent. No intra-operative complications were observed, whereas we noticed a case of surgical wound dehiscence after surgery. The Hemi-Castaing procedure provided a high lateral ankle stability, with excellent clinical and functional results. In our study, no significant difference in evertor strength was found according to side, and there was no significant change in E/I ratio. Moreover, joint position sense was not impaired. *Conclusion.* According to us, this surgical technique is efficient and safe, providing remarkable outcomes in the treatment of chronic lateral ankle instability. (www.actabiomedica.it)

Key words: ankle, chronic lateral instability, Hemi-Castaing

Introduction

Ankle sprain is very common in those who play a sport such as volleyball, basketball, football and resistance running (1, 2).

In most cases (90% approx.), the traumatic mechanism consists in forced stress in varus and supination of the foot – called "inversion" – which causes variable extents of damage to the external compartment (3).

Anatomically, the external (or lateral) district is formed by the external collateral ligament with its three fasciae (anterior peroneal astragalus, calcaneal peroneal, posterior peroneal astragalus) and by the anterior and posterior peroneal-tibial ligament (4).

The lesions, caused by the dynamics of inversion described above, can vary from the simple sprain, to the more or less extended fracture of the external capsular-ligament.

Many cases obtain a discrete functional recovery thanks to conservative treatments such as medical and physical therapies, mobilisation and kinesitherapy (5, 6).

Nevertheless, in a small number of subjects, chronic ankle instability remains and requires surgical treatment.

The surgical techniques available include anatomic repair of the injured ligament through direct suture (7), and techniques called tenodesis reconstruction, where several tendons are used as a means to contain the articular deficiency. The tendon most frequently used for the treatment of chronic ankle instability is the peroneus brevis (8).

In 1984 the surgeon Castaing devised a technique in which this tendon was sectioned and used entirely to recreate lateral ankle stability (9, 10).

This technique was later modified using only half of the tendon, leaving the other half anchored to the base of the fifth metatarsal, and for this reason it was given the name of Hemi-Castaing technique (11-13).

The purpose of this study is to assess the outcomes from the use of the Hemi-Castaing procedure using the hemi-tendon of the peroneus brevis, on a population of patients who are engaged in sports activities and suffer from chronic ankle instability.

Materials and methods

35 patients (12 females and 23 males) with an average age of 31 years (range: 18-52), took part in this observational study conducted in the Casa di Cura "Prof. Nobili" between January 2011 and December 2017.

All patients played sport at a competitive non-professional level. The study was approved by the ethical committee of the Institute in which the research was carried out and the patients gave their informed consent.

The surgery was conducted on the right ankle in 19 patients and on the left ankle in 16 patients. In one patient both ankles were operated, at different times.

The follow-up protocol in our facility consisted of a control at 30, 60, 90 and 180 days with a clinical examination, and then every year.

The average follow-up was 54.2 months.

The pre-surgery diagnosis was chronic lateral ankle instability in all cases for which conservative treatments had not been effective.

At the physical examination, all patients presented a positive anterior drawer sign and a positive Tilt test, with a history of frequent episodes of sprain in inversion.

Surgery

On the lateral side of the ankle, a retromalleolar curvilinear incision of 8 cm of length was made centred at the apex of the peroneal mallelous.

Having identified and cut the sheath, the long and short peroneal tendons were identified.

At the upper end of the cutaneous incision, the peroneus brevis tendon was sectioned longitudinally in half, forming two hemi-tendons of equal diameter.

The anterior hemi-tendon was then sectioned proximally and separated from the posterior half for the entire length of the tendon, up to 4 cm from its insertion at the base of the 5th metatarsal (Figure 1A).

On the distal end of the fibula, a tunnel with a diameter of approx. 0.5 cm was created in a caudocranial direction (Figure 1B).

The free proximal end of the hemi-tendon of the peroneus brevis, prepared in advance, was then passed through the fibular tunnel (Figure 1C).

Maintaining the ankle at 90° and slightly in eversion, tension was applied to the neo-ligament forming a "loop" with the fibula, and this was then sutured with the distal tendon, assessing the stability during surgery (Figure 1D).

The area was then sutured in layers, using metal stitches for the skin.

All patients were operated using spinal anaesthesia and the procedure lasted 30 min on average.

Postoperative period

The limb was immobilised in a cast and the patient was not allowed to put load on it for at least 30 days.

The patients were submitted to anti-thrombotic prophylaxis with low molecular weight heparin (Enoxaparin Sodium, 4000 U.I. 1 fl/dy sc) for 30 days and antibiotic coverage with amoxicillin-clavulanate 2 tablets/day for 7 days and NSAIDs if required.

The use of PEMF (Pulsating Electro Magnetic Fields) was also recommended for the ankle, for 6-8 hours a day.

During the surgical procedure and in the follow-up period the intra and post-operative complications were assessed.

Results

After 30 days, the cast and stitches were removed.

The patient was then allowed to apply total load assisted by two crutches for 7 days, and subsequently

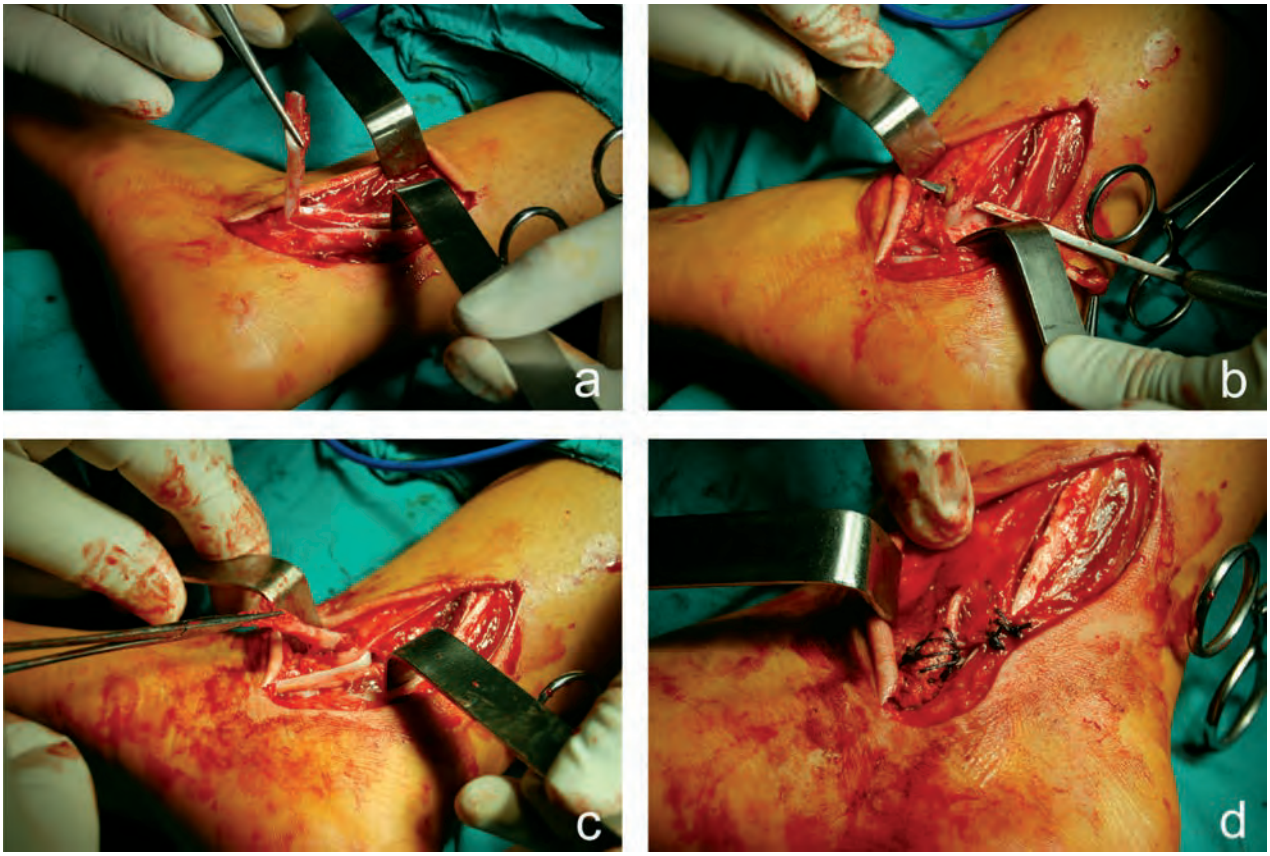

Figure 1. Procedure of reconstructive tenodesis according to Hemi-Castaing. The details are set out in the section entitled "Surgery"

to walk with a single crutch for another 7 days and then without assistance.

NSAIDs were prescribed as needed, low molecular weight heparin for 7 days and anti-oedema medications for 15 days.

The patients then undertook a rehabilitation-physiotherapy programme, which included:

- exercises for proprioceptive re-education;
- methods of gait re-education;
- assisted active and passive ankle mobilisation;
- isometric and isotonic enhancement of the triceps surae muscle and of the tibial and peroneus muscles;
- manual lymph drainage;
- tecar therapy.

After 30 days, following a new check-up, the patients undertook a program of isokinetic enhancement and sport specific re-education.

No complications occurred during surgery, but one case of wound dehiscence occurred in the post-operative period.

Of the 35 patients included in our study, all returned to play sport at a competitive non-professional level between 80 and 100 days from the procedure.

The stability recreated with the methods has been excellent in all cases and patient satisfaction is high, and in no case have new distortions occurred.

Discussion

Assessing the results emerged from our study, we have noted how the Hemi-Castaing procedure was able to contribute elevated lateral stability to the articulations submitted to the surgical procedure.

Literature presents several studies in which the original Castaing technique has been used (11, 14, 15).

Among these, the work by Mabit *et al*. has examined the outcomes from the use of this technique, but

the results have been relatively unsatisfactory (from good to excellent in 70% of patients treated) (11).

Furthermore, in the study by Cañadell *et al.*, out of the 13 patients analysed with a follow up of 2.4 years and submitted to the Castaing procedure, 92% underwent to the new surgical procedure (14).

These results, judged of lower quality to the other non-anatomic reconstructions available, could be due to the reduced capacity of resistance to inversion (approx. 8-9%), caused by sacrificing the peroneus brevis envisaged by the original Castaing technique (16).

This tendon is responsible for the lateral stability of the ankle and subtalar joint.

It is for this reason that it was decided to modify the original technique, maintaining a hemi-tendon of the peroneus brevis in its journey to the bone insertion on the 5th metatarsal (17).

Though the tendon is not completely sectioned, some authors have raised doubts on the effective lateral stability following surgery and on the possible reduction in the eversion force provided by the peroneus muscles (18, 19).

Nonetheless, in our facility, using the modified technique of Hemi-Castaing, we noted that all the patients operated had good to excellent results.

In no case was it necessary to undergo a new surgical procedure for recurrence of the instability or for proprioceptive problems with the ankle.

These results concur with what is set out in literature: in a study by Baray *et al.*, who retrospectively assessed 21 patients who underwent Hemi-Castaing surgery, the results were good or excellent in more than 85% of patients (20).

In agreement with what is described in this last article, we have also noted a reduction in the eversion force of the peroneus muscles, and no alterations in the eversion/inversion ratio (E/I ratio), independently of the side treated (Figure 2, 3).

In conclusion, analysing the data presented in 2011 at the Symposium of the French Society of Or-

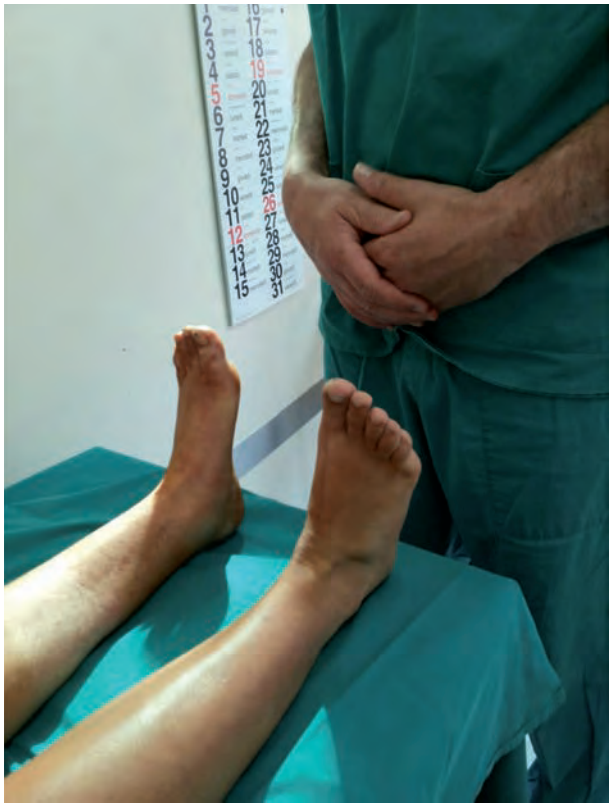

Figure 2. Post surgery clinical check-up

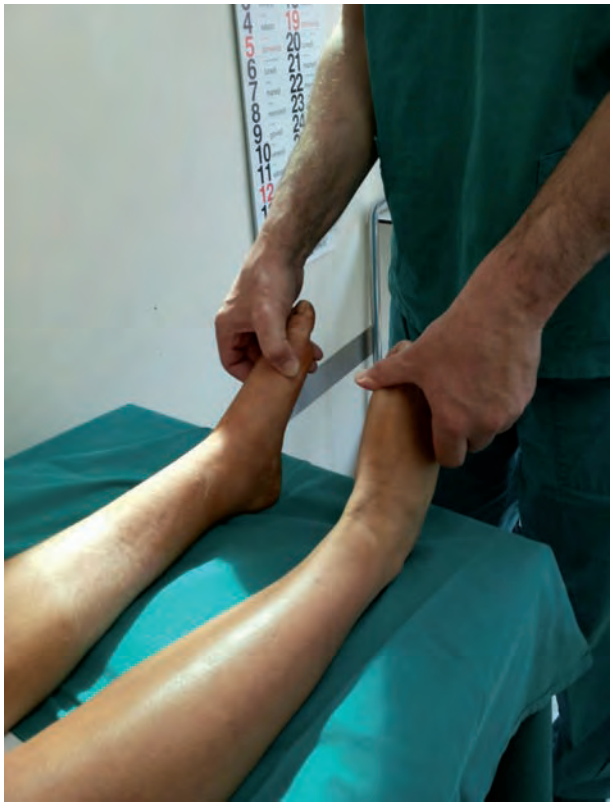

Figure 3. Post operative clinical check-up

thopaedic surgery and Traumatology (*Societé française de chirurgie orthopedique et traumatologique* – SoFCOT), 92% of the 51 subjects treated with this technique of ligamentoplasty has attained a score from good to very good (11).

Conclusions

From the results of our 7 years case studies, we can state that the technique of reconstructive tenodesis by Hemi-Castaing has appeared safe and effective, providing excellent functional results.

Furthermore, preparation of the hemi-tendon of the peroneus brevis caused neither a reduction in the eversion force of lateral muscles nor an alteration to the proprioceptive ability of the ankle.

For these reasons, our facility increasingly proposes the Hemi-Castaing surgical procedure to treat chronic lateral ankle instability.

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Original article

The management of syndesmotic screw in ankle fractures

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Summary. *Background and aim:* There is a wide debate about the number, diameter and length of the syndesmotic screw and necessity and timing for its removal. The aim of this study is to determine whether functional and radiological outcomes differ in patients operated for Weber type B and C ankle fractures who had syndesmotic screws removed (group 1) compared to those who did not (group 2). Furthermore, authors want to define if it is really necessary to remove this device and its correct timing. *Materials and Methods:* 90 patients were eligible for the study. The functional outcomes were analyzed 1 year after surgery using OMAS and AOFAS scores. Radiographic evaluation assessed the tibiofibular distance immediately and 12 months after surgery and fracture's healing. *Results:* Clinical and x-rays results were similar in both groups at follow-up. *Discussion:* Fractures with interruption of syndesmosis are lesions that, if not well treated, are complicated by joint stiffness, residual pain and post-traumatic osteoarthritis. Syndesmotic screw removal is not routinely performed, thus accepting the risk of rupture but avoiding a new surgery. *Conclusions:* Results observed suggest that syndesmotic screw removal is not necessary. If surgeon decide to remove this device correct timing is mandatory in order to obtain satisfactory long-term results. (www.actabiomedica.it)

Key words: ankle, fracture, syndesmosis, screw, fixation

Introduction

Ankle fractures occur with an incidence of 107-148 per 100,000 in the adult population (1, 2). The mechanism of injury is mainly a traumatic event in external rotation with the foot supinated (SER) or pronated (PER), as described by Lauge Hansen (3). The consequence is often a Denis-Weber Type B or C lesion associated to syndesmotic injury occurring in up to 40% of all Type B injuries, and up to 80% of all Type C (4). Anatomical restoration and stabilization of the disrupted distal tibiofibular syndesmosis is essential in order to prevent changes in contact load and posttraumatic osteoarthritis, and to improve functional outcomes (5-8).

Characteristic of syndesmotic fixation is a font of wide debate among orthopedic surgeons. There is no consensus regarding the number, diameter and length of the syndesmotic screw and necessity and timing for its removal (9-12). This study has the aim to determine whether functional and radiological outcomes differ in patients operated for Weber type B and C ankle fractures who had these screws removed compared to those who did not. Furthermore, authors want to define if it is really necessary to remove this device and its correct timing.

Materials and methods

This study was conducted in accordance with the principles of Declaration of Helsinki. All patients signed informed consent about the treatment they were subjected and the processing of their personal data.

Adult patients affected by Weber B and C closed fractures and synthesized with plate and screws (ORIF) associated to syndesmotic fixation between

January 2010 and July 2017 were included. Each case was identified from a patient information database at the University Hospital of Parma. Patients with their charts or radiographs unavailable or incomplete were excluded. Exclusion criteria were also the development of postoperative infection and hardware failure and the need of additional surgery due to complications. Age and gender, mechanism of injury and characteristics of fractures (affected side and fracture type) were extracted from the database and analyzed. All subjects had syndesmotic fixation with 1 or 2 3.5mm screws with a tricortical placement. Patients were divided in 2 groups: group 1 included subjects who removed the syndesmotic screw and group 2 those who did not.

Postoperatively, all patients were immobilized for 4 weeks without weightbearing. After this period rehabilitation started and progressive loading was allowed.

The choice to retain or remove the syndesmotic screw was based on consultant preference.

A functional evaluation was performed 1 year after surgery through 2 validated scoring systems: OMAS and AOFAS (13-15).

A radiological assessment immediately and 1 year after surgery was done using anteroposterior, lateral and mortise views. Tibiofibular clear space (the horizontal distance between the lateral margin of the posterior tibial malleolus and the medial border of the fibula) (figure 1) was recorded in patients of both groups as well as fracture's consolidation.

All data extracted from the database and collected during the final outpatient clinic examination were introduced into a database (Microsoft Excel). Non-parametric Mann-Whitney U test was used to compare AOFAS and OMAS results. Statistical analysis was performed using SPSS for Windows (version 20.0). Statistical significance was defined as p value of <0.05.

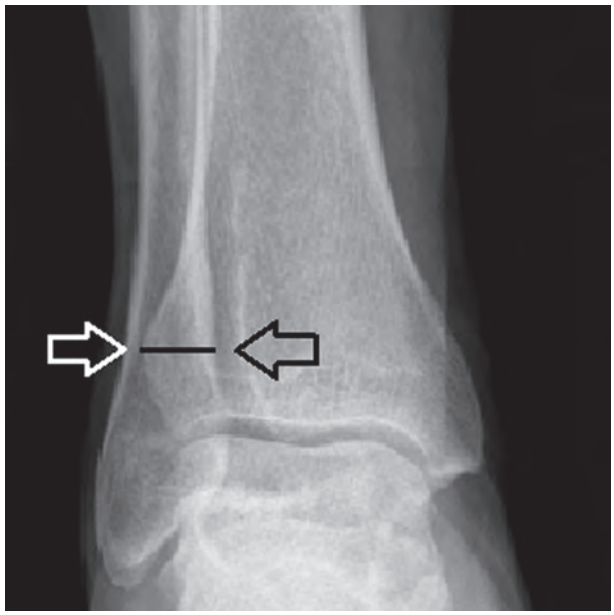

Figure 1. Tibiofibular clear space (line between arrows)

Results

A total of 90 patients were included in the study [54 (66%) were females and 36 (34%) males]. Mean age at the time of injury was 49 years (range 19-71). Fractures occurred more frequently on the left side (54.0%). SER injuries were seen in 15 subjects (14%) and PER injuries in 75 (86%). Thirty-nine patients (43.3%) sustained Denis-Weber B type fractures; the remaining (56.7%) had type C injuries. Based on the state of the syndesmosis screw, group 1 comprised 65 patients (72%) and group 2 25 (28%). In the second group, 8 subjects broke the device but results were similar to others (figure 2). All patients of group 1 removed the screw after a mean period of 7 weeks from surgery (range 6-8) (12). Overall, clinical outcomes for OMAS and AOFAS scores are described in table 1. There were no statistically significant differences in these results between the two groups ($p<0.05$).

Radiological assessment is summarized in table 2. The tibiofibular clear space (normal 0-5 mm), measured immediately after surgery and 1 year later, was similar in group 1 and 2 ($p<0.05$). All fractures healed after a mean period of 3.5 months (range 3-5).

Discussion

This retrospective trial focused on the comparison between two groups of patients. The first group retained the syndesmotic screw, while the second removed it.

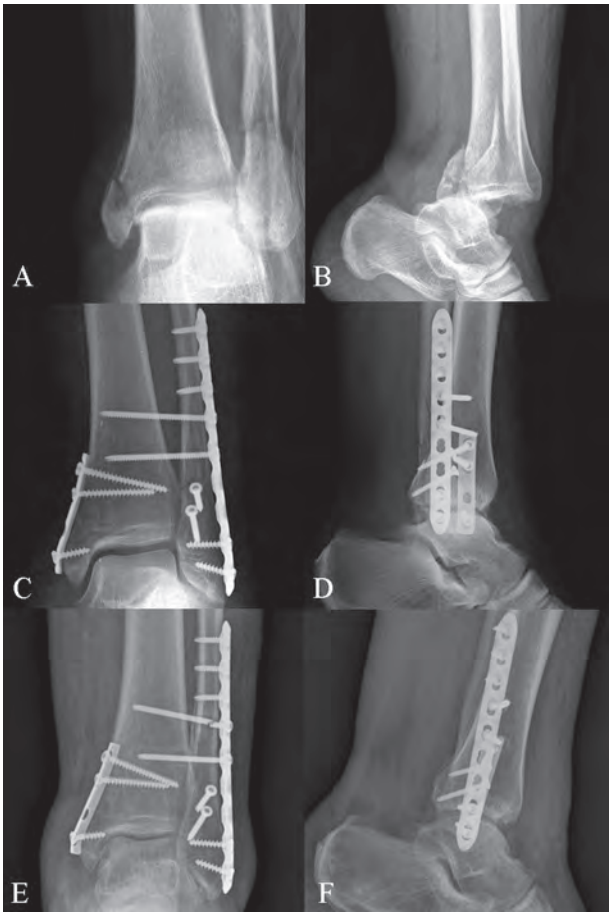

Figure 2. Preoperative x-ray of left ankle fracture (A and B); postoperative views (C and D); radiographs 4 months after surgery with syndesmotic screw rupture (E and F)

Table 1. Clinical outcomes at follow-up

	AOFAS	OMAS
Group 1	94	95
Group 2	99	92.5
Test U Mann Withney	p = 0.056	p = 0.081

Table 2. Radiological outcomes

Tibiofibular clear space (mm)		
	Postoperative x-ray	x-ray at 1 year of follow-up
Group 1	5.0	5.0
Group 2	4.5	5.0
Test U Mann Withney	p = 0.685	p = 0.175

There are no clear indications in literature on the real need for removal of this screw. In a recent literature review, in which seven clinical studies were analyzed, there were no differences in outcomes of patients who maintained or removed this device (16). Its rupture occurs in 29% of cases (16), but numerous studies do not report significant differences in outcomes of patients with intact, broken or removed screw (17-20). Indeed, more recent studies showed that patients with rupture of the screw report a better outcome than the group of patients with intact one (18, 21).

Another report demonstrated that the functional evaluation in patients with retained (intact or broken) or removed screw was not statistically different, although the group of patients with intact screw had a worse ankle function (17). Authors hypothesized that the cause was the decrease of the physiological movement of the fibula in relation to the tibia, which limited ankle's movement (22).

To confirm this, surgeons who are usual to remove the screw state that its removal guarantees a recovery of the biomechanical physiology of the ankle (22-24) with better long-term outcomes (17).

Opponents instead stress that an increased risk of distal tibiofibular diastasis exist after removal (25), as well as an increased risk of infections (18).

Clinical results observed in this report are similar to those described in the literature. In fact, data registered 1 year after surgery were not statistically different between group 1 and 2. Furthermore, rupture did not influence the final outcomes. One of the main problems after ankle ORIF is the management of the postoperative period in which an aggressive rehabilitation and an early weight bearing may induce the rupture of the syndesmotic screw and an early removal may favor distal tibiofibular diastasis. In many cases, the patient struggles to accept the idea of being able to load on the ankle with retained screw, which is essential to avoid the evolution towards a rigid joint. Likewise, the patient does not accept the idea of maintaining a screw that has broken although this does not entail any risk (18, 21). In any case, authors believe that, whatever the treatment performed, the postoperative management has to be the same with an initial period of cast immobilization for at least 4 weeks, thus facilitating the healing of the disrupted soft-tissues structures.

The maintenance of tibiofibular clear space at 1 years follow-up confirms this assumption. Finally, authors wants to stress the importance of removal's timing of the screw which has to be performed not earlier than 7 weeks following ORIF, thus preventing a possible abnormal enlargement of tibiofibular distal joint.

Conclusions

Results observed suggest that syndesmotic screw removal is not necessary. Rupture of the screw does not influence 1-year follow-up outcomes. Removal's timing of the device must guarantee the complete healing of the injured syndesmotic soft tissues.

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Case report

Scapulothoracic dissociation: a devastating "floating shoulder" injury

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Summary. *Background and aim of the work:* The term "floating shoulder" was used in a previous paper to describe lesions of at least two components of the SSSC (superior shoulder suspensory complex), a bony-ligamentous structure of the shoulder girdle. Following this article other types of floating shoulder were described, including scapulothoracic dissociation (STD), a rare lesion with potentially devastating consequences, with detachment of the scapular body from the thoracic wall, with following lateralization of the scapula, fracture of the clavicle or injury of the adiacent sterno-clavear or acromion-clavicular joints. Prognosis and outcome are also negatively influenced by secondary vascular and neurologic injuries. *Methods:* We review the literature on this lesion and we describe two patients with STD, their treatment and outcome. *Results:* Reviewing the literature and analysing our cases, we point out that the STD is often associated with serious general lesions and is indicative of an high-energy trauma. The consequences can be disabling for the upper limb (20% amputation, 50% flail limb) or for the general status of the patient (10% mortality). *Conclusions:* STD must be timely recognized and subsequently properly treated, to avoid the associated general and local injuries (vascular) and subsequently the musculoskeletal lesions. (www.actabiomedica.it)

Key words: scapulothoracic dissociation, high-energy trauma

Background and aim of the work

The 'floating shoulder' is a lesion consisting of ipsilateral fractures of the clavicle and glenoid neck. It was first described by Ganz and Noesberger in 1975 (1). Subsequently, Goss expanded their definition by describing it as a 'double disruption' of the superior shoulder suspensory complex (SSSC) (2).

Oreck et al. in 1984 describe scapulothoracic dissociation (STD) as a rare variant of the floating shoulder, with potentially debilitating consequences. STD consists in a complete disruption of the scapulothoracic articulation with lateral scapular displacement (3-5). Patients usually come to observation with massive soft-tissue swelling of the shoulder due to haematoma and edema, and gross instability of the joint, together with anterior bony or ligamentous lesions such as acromioclavicular separation, displaced clavicular fracture and sternoclavicular disruption (6). Muscular tears (deltoid, pectoralis minor, rhomboid, elevator scapula, latissimus dorsi and trapezius) may also occur (3).

STD always follows an high-energy trauma, more often a motor vehicle accident, and the mechanism of injury is probably the traction caused by a blunt force to the shoulder girdle. It is associated with other body lesions, thoracic trauma in primis, and in 80-90% of the cases with local neurovascular injuries such as plexus or cervical roots avulsion and rupture of subclavian or axillary vessels (3, 4). No open skin wounds are usually found, although open STD has been described (7).

Patients with STD often have a poor functional outcome: 10% die from concomitant traumatic injuries (8). Survivors in 50% of cases have a flail extremity and in 20% of cases require amputation of the upper limb (9).

Methods

We analyse two cases of STD.

Case 1

G.G., male, 50 years old

The patient was referred to our hospital after colliding with a car while riding his motorcycle. He was haemodynamically unstable. After initial x-ray and resuscitative manoeuvres (fluid and blood infusion, intubation, left chest tube), the total body CT scan revealed a subdural haematoma, fractures of C7, T3, T4, T11, T12, left lung contusion, left apical pneumothorax, bilateral fracture of XII rib, left sternoclavicular separation, and scapulothoracic dissociation (Fig. 1) with complete interruption of axillary artery. The left upper limb was cold and pulseless.

The patient was immediately treated for the vascular injury. Angiography (Fig. 2) with endovascular recanalization was tried, unsuccessfully; therefore an axillo-brachial by-pass with autologous saphenous vein graft was done. The brachial plexus was completed disrupted and a large haematoma was evacuated from the axilla. He was then taken to ICU for observation and continued resuscitation.

On 1st post-op day, as a compartment syndrome after revascularization was present, volar and dorsal fasciotomies of the left upper limb were done. Following an infection of the fasciotomy wounds, an above-the-elbow amputation was redeemed necessary because of wet gangrene.

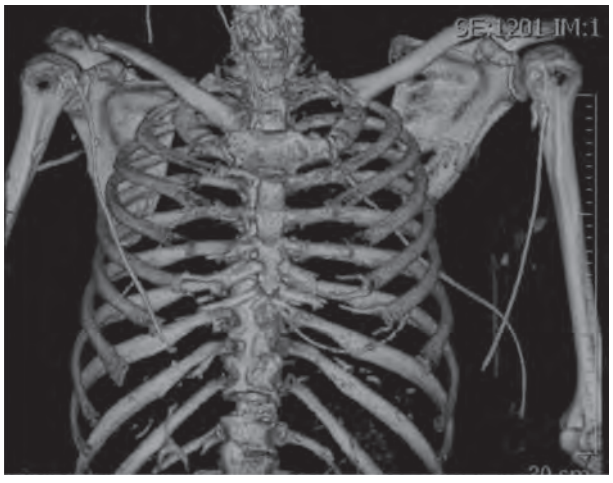

Figure 1. CT 3d reconstruction: left scapulothoracic dislocation

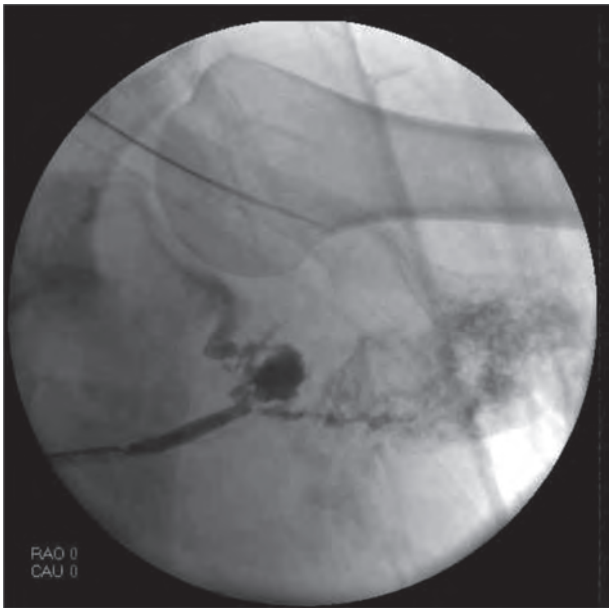

Figure 2. Angiography showing bleeding from complete lesion of the axillary artery

The neurosurgeons performed cervical and dorsal decompression and fixation (incomplete tetraplegia). The patient was also treated surgically for a right wrist fracture and conservatively for a right undisplaced tibial plateau fracture.

The patient underwent an i.v. antibiotic treatment for sepsis while in hospital.

The patient was discharged 50 days after admission and transferred to a neurologic rehabilitative hospital.

Case 2

M.X., female, 23 years old

The patient was victim of a high speed car accident, ejected from the car. Because of intense dyspnea she was intubated on the scene and bilateral hemithorax decompression was performed.

On arrival at our hospital she was haemodynamically stable: X-Ray (ATLS protocol) and total body CT scan detected bilateral lung contusion with bilateral pneumothorax, D8-D9 disc lesion, grade I spleen contusion , left forearm fracture, subluxation of the left knee, left clavicle fracture (middle third), scapulothoracic dissociation (Fig. 3) and a mandibular fracture. The clinical evaluation of the left upper limb revealed

a normal radial and ulnar artery pulse; no neurological impairment was noted after the extubation in ICU.

In the course of the following days the patient underwent surgery to fix the dorsal spine, the mandibular fracture, the left forearm fracture and the knee subluxation. We also provided the open reduction and internal fixation of the left clavicle fracture with a 3.5 plate (Fig. 4).

On the 5th day the patient was transferred to the ICU of her local hospital.

The patient was contacted by telephone 18 months after the hospital admittance. She was asked to answer the DASH score questions and she scored 14.2, revealing a satisfying shoulder functionality, with only mild limitation in some overhead activities.

Results

Reviewing the literature and our cases, we find overlapping data.

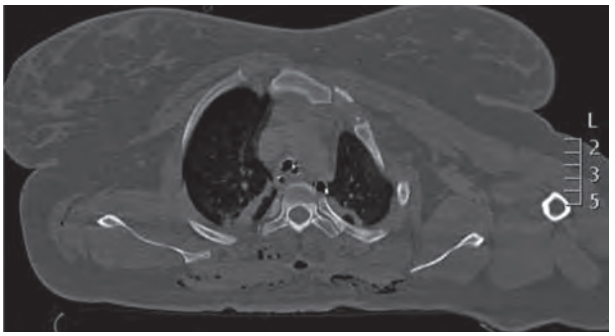

Figure 3. CT axial cut: left scapulothoracic dislocation

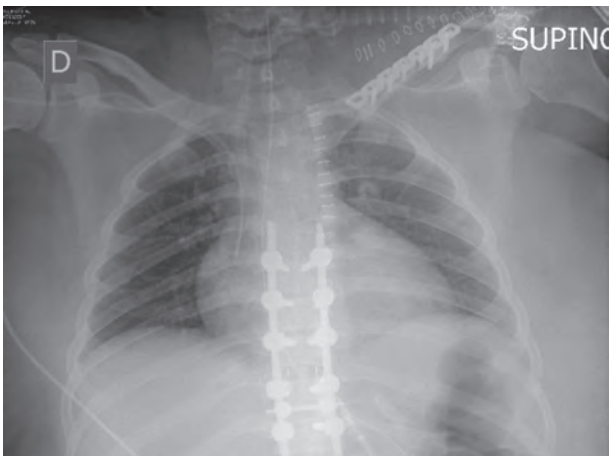

Figure 4. x-ray of post-operative plating of the left clavicle

First of all, STD is always caused by high-energy trauma and patients always need an emergency cardiopulmonary resuscitation in accordance with the ATLS protocol. Given the high probability of associated life-threatening injuries with STD, these injuries must be the first evaluated and treated.

Once the STD is recognized it is necessary to rule out any lesion of the subclavian or axillary vessels and of the brachial plexus. The latter is very difficult to evaluate because these patients are often sedated or intubated, but an accurate and prompt diagnosis is essential both for the prognosis and for a surgical decision in case of complication (amputation versus salvage of the limb).

In some cases Magnetic Resonance Imaging (MRI) may be used to reveal lesions of the cervical roots or of the brachial plexus, or their consequences such as pseudomeningocele. Upper extremity electromyography (EMG), even with some limitations, can be helpful in detecting the involved nerve roots; this study should be done at least three weeks after injury (3, 11). The repair of a plexus rupture in STD is seldom described in the literature(6).

In line with what appears in literature, our cases have different outcomes: one patient was amputated above the elbow, the second reached complete healing with good functionality of the upper limb. Regarding the functional outcome, the worst prognostic factor is an arterial rupture, followed by the complete avulsion of the brachial plexus (3, 9). A venous lesion may be treated by ligation without any consistent consequences (12).

After salvage of the limb, orthopaedic surgery would be the next step. The musculoskeletal injuries described about the shoulder girdle involve a clavicle fracture in 55%, acromion-clavicular joint separation in 25%, and sterno-clavicular joint separation in 20% (10). In case of clavicle fracture open reduction and internal fixation with a plate is the gold standard. In case of acromioclavicular or sterno-clavicular separation a strong construct is needed, different from standard fixation of a dislocation (10). The stabilization of the shoulder is also needed after a vascular repair procedure to protect the vessel.

An early above-the-elbow amputation can sometimes modify the clinical trend and the prognosis of the patient. In case of patients' refusal, a delayed am-

putation has to be considered, especially in absence of any clinical and EMG recovery, to avoid further delay in the rehabilitation program. This operation can decrease the causalgia, especially if the symptoms last for less than one year (12).

Conclusions

STD is a devastating and potentially debilitating injury, with different musculoskeletal and neurovascular injuries. Zelle (9) classified STD in 4 types; type 1 with musculoskeletal lesion alone while the others classified according to increasing neuro-vascular lesions.

On initial x-rays a scapula that does not overlap the thoracic wall (usually ribs 2-7) is highly suspicious of a STD: this image means a lateralization of the scapular body (11). An attempt to measure the distance between the medial border of the scapula and the midline of the spine proved to be difficult and not precise. The axial view of the CT scan proves to be paradigmatic, revealing a separation of scapular body from the thoracic wall, with lateralization compared to the contralateral (Fig. 3).

STD might be overlooked, because of the often severe associated injuries, or underdiagnosed and treated as a "common" clavicular fracture. In fact, initial chest radiographs are often not properly aligned in a true anteroposterior position, and sometimes it is difficult to identify the lateral deviation of the scapula ,pathognomonic sign of this condition. The result of a "missed diagnosis" of STD is lack of treatment of potentially life-threating vascular lesions or a non correct treatment of the damaged shoulder girdle.

After adequate resuscitation, the initial treatment of STD should be the repair of eventual vascular lesions, that can lead to the haemodynamic instability of the patient and must therefore be urgently addressed.

We strongly recommend the fixation of the clavicle fracture or of the adiacent joint separation in case of STD; there is always a gap between the medial and the lateral stump of the fracture due to the lateralization of the whole upper limb. This gap could easily lead to a non-union if not surgically treated. Open reduction and internal fixation with a compression plate should be preferred to an intramedullary device, the latter giving less stability and no compression to the fracture.

An upper limb amputation always leads to an extremely low quality of life, and every attempt to salvage should be done. On the other hand the general status, the vascular and neurologic problems, and the bacterial colonization may strongly recommend a radical treatment; in this case the amputation should be promptly done, avoiding further complication of the general status. Furthermore early amputation can be associated with quicker back to work and better pain relief (3).

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Case report

Annular ligament repair using allograft for the treatment of chronic radial head dislocation: a case report

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Summary. *Background:* The annular ligament has a crucial role in the radial head stability and it is critical to the proper functioning of the proximal radio-capitellar joint. Its chronic injury may lead to radial head instability, elbow pain with decrease in motion and valgus deformity. *Method:* We present the case of a 53-year-old heavy laborer who reported a complex trauma of the right upper limb with a Floating Elbow Injury, associated to an open Monteggia fracture-dislocation. One month later, despite the definitive fixation with plates of both the forearm and the supracondylar fractures, X-rays showed the persistence of the radial head dislocation. A triceps autograft reconstruction for treating the chronic radial head dislocation, as described in literature, was not indicated in our patient, due to the recent surgery at the distal humerus site. Thus, it was decided to proceed to allograft reconstruction using a peroneal tendon from a cadaveric donor, fixed by modified Bell-Tawse Technique. *Results:* Two years after the surgery, x-rays showed the complete fractures' healing; however a radial head notching was found. **C***onclusions:* Allograft reconstruction of the annular ligament deserves to be considered as an adequate technique, whenever the surrounding soft tissues are critically compromised. In literature, the radial head notching complication is reported to be up to 36 %, and it may be related to the surgical technique, regardless of the graft used. (www.actabiomedica.it)

Key words: annular ligament repair, allograft reconstruction, radial head dislocation

Introduction

The annular ligament plays a critical role in maintaining the position of the radial head, and the stability of the proximal radio-ulnar joint (PRUJ). PRUJ disruption distinguishes the Monteggia fractures from the other injuries associated with the radio-capitellar dislocation.

In cases of complex Monteggia fracture-dislocation, the anatomical restoration of the ulnar length and alignment is mandatory in order to obtain a congruent PRUJ (1, 2). Nevertheless, even if an appropriate surgical treatment is performed, Monteggia injuries may have a high rate of complications (3, 4), such as the chronic dislocation of the radial head. This is defined as a dislocation which is still present 4 weeks after the trauma. The causes may be located in residual ulnar deformity after internal fixation, in failure of the annular ligament healing, or in both. The resulting radial head instability may lead to elbow pain, decrease in motion, and valgus deformity (5, 6).

Case presentation

A right-hand-dominant 53-year-old heavy laborer reported a high-energy fall on his outstretched right arm. He was admitted to our Department having sustained an open fracture of his right forearm and an apparent elbow dislocation. No radial and ulnar pulses could be tracted at the wrist. X-rays revealed a supracondylar humeral fracture associated to an open Monteggia fracture-dislocation, classified as type IV according to Bado's classification. According to Gustilo-Anderson classification of the open fractures, the

soft tissue injury was classified as III C due to the involvement of the brachial artery.

An arterial thrombectomy using a Fogarty catheter was first performed, with the complete restoring of the distal pulses. However, an actual brachial artery damage was not found; a possible explanation could be an intensive artery spasm caused by the high energy of the trauma. It was decided then to proceed to the open reduction and plate fixation of the supracondylar humeral fracture, and to reduction and fixation of the forearm fractures using TEN nails. It was also performed a K-wire temporary stabilization of the humero-radial joint to avoid the radial head subluxation. Appropriate antibiotic coverage with Cefazoline and Gentamicin was immediately started.

Four weeks later, at the K-wire removal, X-rays revealed the radial head dislocation relapse (Fig. 1). The skin wound at the open fracture site was completely healed, and laboratory tests showed no signs of infection. Therefore, the patient underwent second surgery in order to obtain the anatomical reduction of the forearm fracture. TEN nails were removed and definitive fixation was performed using plates. No signs of PRUJ instability was apparently found during the intra-operative dynamic tests. Unexpectedly, the post-operative x-rays showed the persistence of the radial head dislocation.

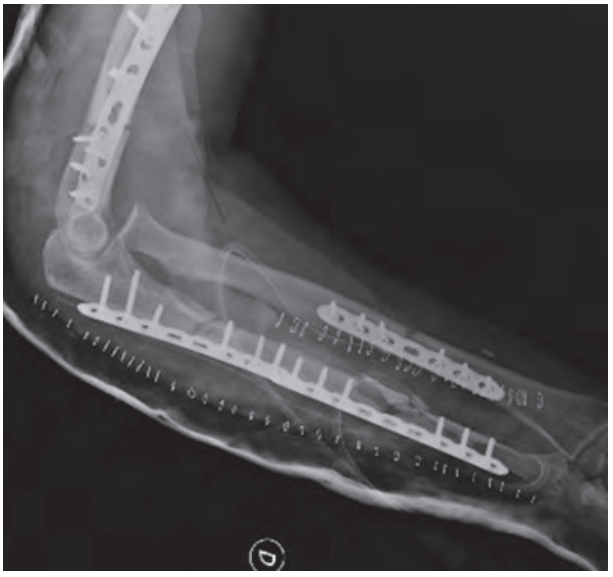

Figure 1. The persistence of the radial head dislocation relapse at the 4-week x-rays follow-up

A triceps autograft reconstruction for treating the chronic head dislocation, as described in literature, was not indicated in our patient, due to the recent surgery at the distal humerus site. Thus, it was decided to proceed to allograft reconstruction using a peroneal tendon from a cadaveric donor, fixed by modified Bell-Tawse technique (Fig. 2).

A Speed and Boyd's approach was used to access the elbow. The exuberant tissue which had grown in the radial notch of the ulna was removed. The proximal ulna was decorticated at the level of the native annular ligament. A 12 cm x 4 mm strip of peroneal tendon from a cadaveric donor was prepared. A 4.5 mm bone tunnel was drilled through the ulna. The tendon was passed through the ulnar tunnel, then around the radial neck prior to its reduction. The graft was tensioned keeping the forearm in neutral position, and it was anchored on the medial side using a non absorbable suture. After surgery the elbow joint was immobilized in a fixed 90° elbow splint for three weeks.

At the splint removal, the patient was discharged to the Rehabilitation Unit to start a targeted rehabilitation program.

At the two-year follow-up the right elbow A-ROM was 5 degrees extension, 130 degrees flexion, 80 degrees supination, 5 degrees pronation. X-rays showed the complete fractures healing; however a radial head notching was found (Fig. 3).

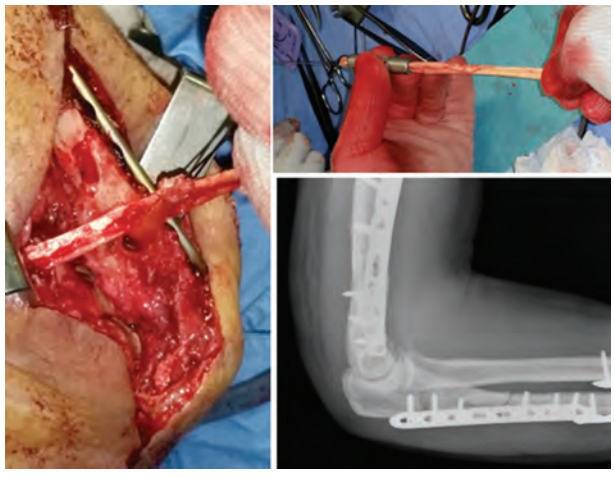

Figure 2. The allograft reconstruction with peroneal tendon from a cadaveric donor – intra-operative and post-operative

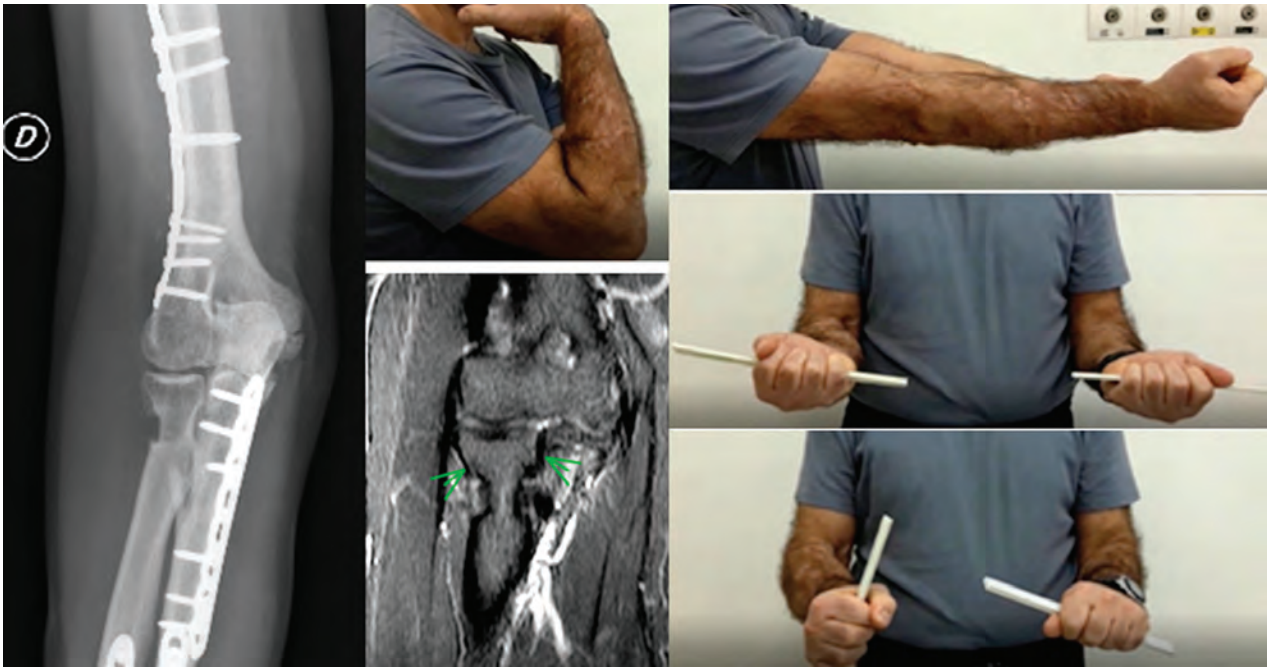

Figure 3. The clinical outcome and the radial head notching at the two-year follow-up

Discussion

The patient in herein study, who presented a rare combination of a Floating Elbow Injury associated to a type IV Monteggia fracture-dislocation, developed a chronic dislocation of the radial head.

The reasons which could have led to this complication were analyzed.

The aim of the second surgery was to obtain an anatomical reduction of the forearm fracture, which is mandatory to restore the congruity of the PRUJ. Nevertheless, it was not achieved. A possible reason is that it might had been underestimated the role played by the annular ligament integrity.

Many techniques of autograft reconstruction, for the treatment of the chronic dislocation of the radial head, have been described in literature.

In 1965, Bell Tawse et al. described a technique for the annular ligament reconstruction (ALR) using a strip from the central portion of the triceps brachii tendon. The tendon strip was left attached to the ulna, passed from posterior to anterior around the radial neck and fixed to the proximal ulna through a drill hole (7.)

In 1969, Boyd et al. also described a technique using a strip from the triceps tendon which was passed around the radial neck from posterior to anterior without drilling any bone tunnel through the ulna (8).

In 1977, Lloyd et al. introduced a modified Bell-Tawse technique using the lateral bundle of the triceps tendon (9).

In 1999, Seel and Peterson described a two-hole technique using a tendon bundle from the triceps brachii (10).

Recently, other techniques using the brachioradialis tendon, the palmaris longus tendon, the extensor carpi radialis tendon and the superficial head of the brachialis muscle have been proposed (2, 6, 11-13).

Each technique previously listed, considers the use of autografts harvested from the structures surrounding the elbow. This was not indicated in our patient due to the recent surgery at the distal humerus site, and the soft tissue damage related to the open fracture of the forearm.

Therefore it was decided to proceed to allograft reconstruction using a peroneal tendon from a cadaveric donor, and a satisfying capacity of the elbow was restored.

The radial head notching which was found at the 2-year follow-up x-rays was a predictable complication, not so rare in literature, regardless of the graft used (14, 15). It may be related to the surgical technique, due to a residual ulnar bony deformity that stretches the neo-ligament, or due to a high tension made by the ligament suture, which constricts the radial neck during the forearm prono-supination (16, 17).

Some authors recommend to measure the maximum ulnar bow and add an osteotomy in cases of apparent ulnar bowing, to avoid the neo-ligament failure (18, 19).

Some authors also recommend the use of absorbable sutures. The suture would retain 100% strength for about two weeks, after which it would begin to dissolve avoiding an excessively high pressure exerted by the neo-ligament (17, 20).

In conclusion, we assume that allograft reconstruction deserves to be considered as an adequate technique for the treatment of the chronic annular ligament disruption, whenever the surrounding soft tissues are critically compromised.

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Case report

Unusual case of hypotenar Hammer Syndrome and carpal tunnel syndrome association

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Summary. *Background and aim of the work:* Hypothenar Hammer Syndrome is a relatively rare disease process caused by repetitive stress or injury to the hypothenar eminence leading to chronic injury to the ulnar artery. Our study reports an unusual case. *Methods:* A 57 years old Plumber presented in April 2016 with a history of constant pain and recurrent paresthesia involving the fingers of the right hand for several months, over the previous 1 year, his hand had become more intolerant of exposure to cold temperatures. Angio-RNM and electromyography were performed and showed a severe double compression of ulnar and median nerve and an ulnar artery deformity without thrombosis. Surgery was performed under sedation and axillary anesthesia. *Results:* After surgery patient' symptoms immediately improved, and within a few months, his hand had normalized. *Conclusion:* Hypothenar Hammer Syndrome is a rare disease process which manifests in certain occupations and activities that put undue stress on the hypothenar area. Furthermore, the carpal tunnel syndrome, a pressure damage of the median nerve, caused by repetitive manual tasks with flexion and extension of wrist has been added as well as hypothenar hammer syndrome which are vascular damages of hand caused by shock-type application of force. (www.actabiomedica.it)

Key words: hypothenar Hammer Syndrome, ulnar artery, ulnar nerve, median nerve

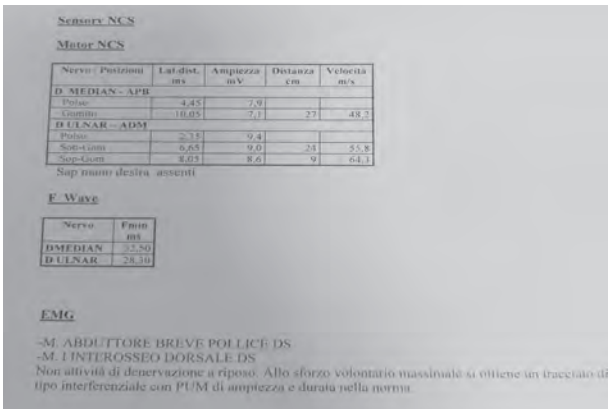
Introduction

Hypothenar Hammer Syndrome (HHS) was initially described by Von Rosen in 1934 and named by Conn in 1970 (1). The superficial palmar branch of the ulnar artery lies directly over the hook of the hamate bone and is therefore susceptible to repetitive trauma, which may result in arterial thrombosis or subsequent aneurysm formation with possible distal embolization (2). Ulnar artery alteration can cause compression of the sensory branch of the ulnar nerve (3). In 2006 a large cohort study revealed the incidence rate for HHS to be 1,6% (4). Although the diagnosis can be confirmed easily with elettromiography and sonography, by showing altered ulnar nerve conduction and irregularity of the superficial ulnar artery (tortuosity, aneurysm, thrombosis), MRI and MR angiography (MRA) provide a comprehensive evaluation of the hypothenar region (5). Artheriography can be used but it is more invasive. There is still no standard treatment for HHS due to difference in clinical symptoms and less of previous study information (6). Initial descriptions of treatment of HHS involved primarily conservative therapy: avoidance of using the palm to strike object, smoking cessation, and use of calcium-channel blockers (2). More recent reports, however, have emphasized surgical treatments, such as thrombolysis, aneurysm exclusion and arterial reconstruction (1, 7, 8).

We report a case of a patient with severe double compression of ulnar and median nerve and an ulnar artery deformity without thrombosis. Accordingly, we present patient's records, clinical examination, imaging data and the management employed.

Case report

The authors have obtained the patient's informed consent for print and electronical publication of the case report. In April 2016, a 57 years old Plumber showed up at our clinic, with a history of constant pain and recurrent paresthesia involving the fingers of the right hand for several months, over the previous 1 year, his hand had become more intolerant of exposure to cold temperatures. Physical examination revealed a positive Tinel for both median and ulnar nerve. Both radial and ulnar artery pulse was normal and Allen's test was also normal. No ischemic lesions were noted in the finger of the right end. Capillary refill was delayed in all finger of the right hand compared with the uninvolved extremity. The patient exhibited good general condition, he was a smoker (15 cigarettes a days). No other co-morbidities were noted. The patient subsequently underwent elettromiography which confirm a severe double compression of both ulnar and median nerve (Fig. 1). Magnetic resonance angiography showed ulnar artery tortuosity without thrombosis. Serological and hematological tests were normal. Surgical procedure was performed under sedation and axillary anesthesia. A longitudinal type incision was made from the distal portion of forearm over the ulnar and hypothenar eminence area and the Guyon tunnel and the surrounding area were explored. Separation of the ulnar artery from the ulnar nerve was started slightly above the level of the wrist, which showed a perivascular inflammatory adhesive reaction without sign of thrombosis. Subsequently a syndesmotomy was performed on the ulnar side of the carpal ligament. There were no postoperative complications and all symptoms (pain, paresthesia and intolerance to cold temperature) were resolved. The patient was discharged home the day after operation on full dose aspirin. After 2 months patient returned to work, he stopped smoking. At the latest follow-up he had no kind of trouble and normal hand function (Fig. 2, 3, 4).


Sensory NCS

Motor NCS

Nervo: Posizioni	Lat.dist. ms	Ampiezza mV	Distanza cm	Velocità m/s
D_MEDIAN – APB				
Polso	4,45	7,9		
Gomito	10,05	7,1	27	48,2
D ULNAR – ADM				
Polso	2,35	9,4		
Sot-Gom	6,65	9,0	24	55,8
Sup-Gom	8,05	8,6	9	64,3

Sup mano destra assenti

F Wave

Nervo	Fmin ms
DMEDIAN	22,50
D ULNAR	28,30

EMG

-M. ABDUTTORE BREVE POLLICE DS
-M. I INTEROSSEO DORSALE DS
Non attività di denervazione a riposo. Allo sforzo volontario massimale si ottiene un tracciato di tipo interferenziale con PUM di ampiezza e durata nella norma.

Figure 1. Elettromiography

Discussion

The ulnar artery has a superficial course at the wrist as it crosses laterally to the hook of hamate carpal bone (Guyon tunnel). This special anatomy makes the ulnar artery more prone to repetitive trauma in certain professional and sport activities (9). HHS is most commonly observed in people exposed to acute blunt, vibratory, or repetitive chronic trauma to the hypoth-

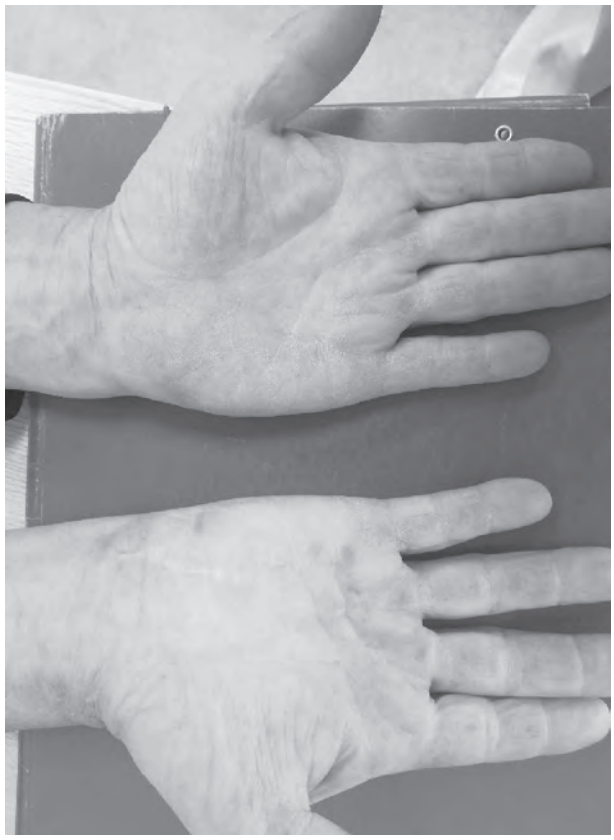


Figure 2. Clinical photos at 1 years follow-up

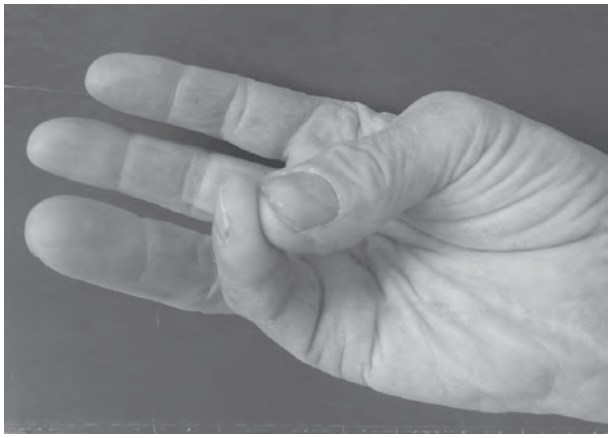


Figure 3. Clinical photos at 1 years follow-up

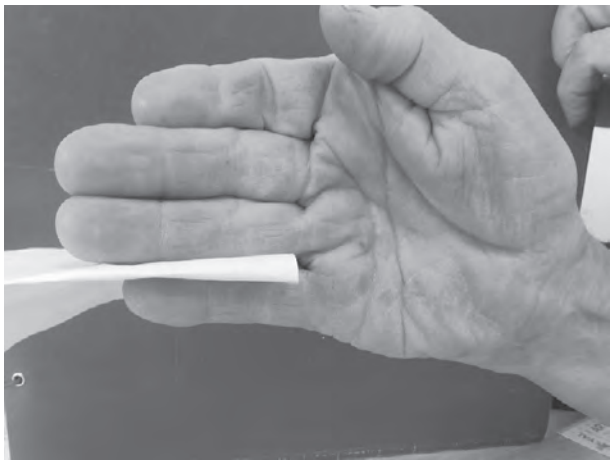


Figure 4. Clinical photos at 1 years follow-up

enar muscle like in carpal tunnel. However, association between carpal tunnel syndrome and ulnar nerve entrapment at wrist remains controversial (10). A review of current literature reveled that reports related to management of hypothenar hammer syndrome are limited (11,12).

Conclusion

Symptoms at the time of presentation are dependent on the extend of arterial damage. Timely diagnosis of HHS is important for minimizing potential serious complication (13). In delayed diagnosis, it may be possible to have further thrombosis of the run-off artery and the patient may suffer from the complication of HHS such as distal embolization, hand claudication or amputation. Early diagnosis and treatment may improve treatment outcome. There is no consensus concerning the diagnosis and treatment of HHS. In addition, the diagnostic algorithm is complex because of the disease's rarity and wide range of symptoms (14). HHS is still under diagnosis and treatment due to unrecognized by the patients and their primary care physician. This case demonstrated the importance of early diagnosis which can avoid serious complication and more aggressive surgery. Further studies regarding management of hypothenar hammer syndrome are needed to delineate an effective standard treatment regimen.

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Case report

Necrotizing fasciitis of the hand: a case report

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Summary. Necrotizing Fasciitis is a rare life-threatening infection, usually polymicrobial, that frequently affects the extremities in as many as two thirds of the cases. It typically involves primarily the muscular fascia, and then spreads through muscular and subcutaneous tissues. The early diagnosis may be challenging, and appears to be crucial in the management of this condition. We report a case of a 45-year-old man, former drug abuser, diabetic, HCV+, who developed a necrotizing fasciitis of the hand following a minor trauma. Early diagnosis based on clinical, laboratory (LRINEC score) and radiological findings, together with an accurate debridement of the affected site, allowed us to limitate the amputation to the third ray only. The reconstruction with the capitate osteotomy and the coverage with the posterior interosseous flap helped us in further reduction of the functional impairment of the hand. (www.actabiomedica.it)

Key words: Necrotizing fasciitis, LRINEC score, posterior interosseous flap, capitate osteotomy, dishwater-like pus

Introduction

The term "Necrotizing Fasciitis" (NF) refers to a life-threatening infection, with a bacterial aetiology, characterized by a rapid necrosis that primarily involves fascial tissues, and then spreads to muscular and subcutaneous tissues. This condition, also known as "flesh-eating disease" frequently engages limbs, often unilaterally, although some cases of bilateral and multifocal involvement are described in literature (1,2).

The incidence of NF ranges between 0,4 (3) and 1,3 (4) /100 000 according to the country (Canada Vs Florida).

This condition can be classified in 4 clinical forms (5,6) depending on the causative organism: one anaerobic species with one or more facultative anaerobic streptococci (other than group A) and members of the Enterobacteriaceae (7), Haemolytic streptococcus group A, members of the Vibrio ssp, (8) and, at last, fungineal Candida infections (9).

Clinically NF usually presents as an erythema of the skin surrounding the affected area, with unregularly marginated edges, warm to the touch, very painful especially in the early stages; within 3 to 5 days from the onset blisters start to emerge, evolving then in skin necrosis.

Intense fever is a very common finding; at this stage pain and tenderness to the affected area dissolve; this characteristic can actually help in identifying a NF.

Gas formation in subcutaneous tissues is frequent mostly in polimicrobial forms, especially in diabetic patients (10).

The diagnosis is essentially clinical, and can rely on a clinical/anamnestic/laboratory score named LRINEC (11).

A score of 6 or more has a positive predictive value of 92% and a negative predictive value of 96%.

Still, surgical exploration remains the gold standard for definitive diagnosis (12-14).

E.V. antibiotic treatment should be started immediately, together with surgical debridement of affected

tissues, till the possibility of the amputation of the affected limb (15).

In this article we report the case of a patient with a NF of the right hand, focusing on the importance of a prompt diagnosis and treatment.

Case

A 45 y.o. male, unemployed, diabetic (insulin-dependent), HCV+, currently under treatment for a depressive disorder, alcoholic, with a history positive for EV drug abuse until 10 years earlier, was admitted to our E.R. with a swollen and painful hand (Fig. 1, Fig. 2).

He reported a minor crush injury to his right hand between the wings of a gate 3 days before , causing a small wound to the dorsal skin of the proximal phalanx of the third finger.

At first, he started an oral antibiotic prophilaxis with Amoxicilline/clavulanic acid (1 gr x 2/day) and dressed the wound with a topical preparation of gentamicine and steroid.

The patient reported the appearance of an erythema spreading to the whole forearm and swelling of his right hand over the following two days; for this reason he headed to our E.R., where he underwent an X-ray scan of his hand (negative for fractures) and was then hospitalized in the Infectious Diseases department with an initial diagnosis of a post-traumatic phlegmon;

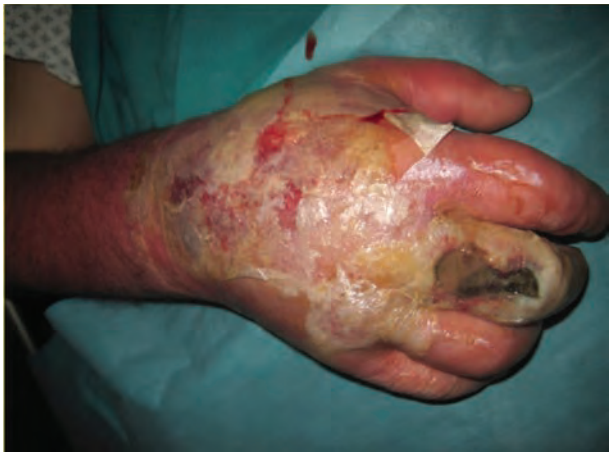

Figure 1. Dorsal and volar aspect of the hand at the admission to our E.R.

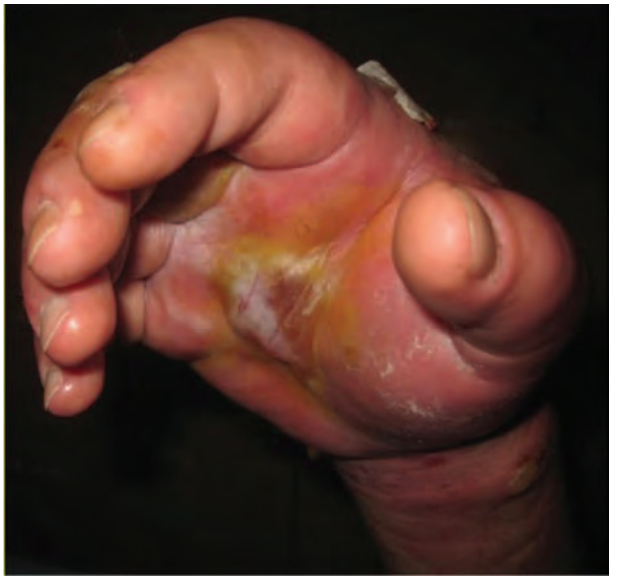

Figure 2. Dorsal and volar aspect of the hand at the admission to our E.R.

thus an E.V. antibiotic therapy has been promptly started (piperacillin/tazobactam and clindamycin).

Blood tests on entry, with regard to the LRINEC score, are reported in (Tab. 1):

The following day, as the symptoms kept worsening, the patient underwent a CT scan of his right hand; in view of the CT scan, we stated the need of a timely debridement, and transferred the patient to our ward.

Intraoperatory findings were compatible with NF, with a malodorous "dishwater-like" pus, trombotic subcutaneous blood vessels, and little-to none resistance to the digital detachment of subcutis from the extensor apparatus to the whole dorsum of the hand (Fig. 3).

The incision for pus drainage was centered dorsally on the third ray, extending to the distal forearm, together with a volar approach for the debridement of all the visible necrotic tissues from the first to the fifth ray. After

Table 1. Serum parameters of the patient on entry in the orthopaedic department with regard to the LRINEC score

WBC	8,2x10^3 u/L	Glucose	14,37 mmol/L
Hb	11.8 g/dL	Serum Creatinine	58.3 micromol/L
Na+	123 mmol/L	CRP	181 mg/L
		Total LRINEC	
		8	

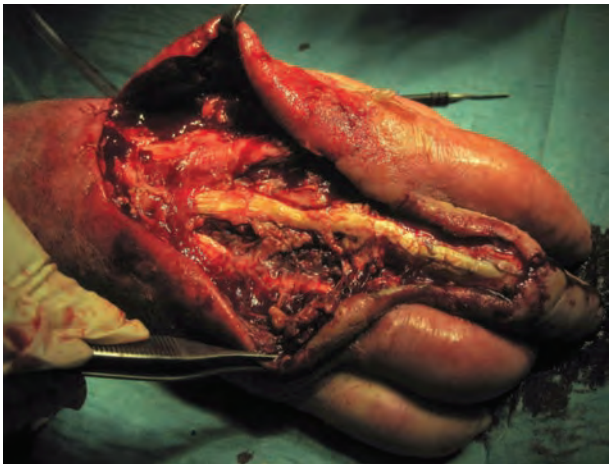

Figure 3. Intraoperative findings during the first debridement surgery (dorsal)

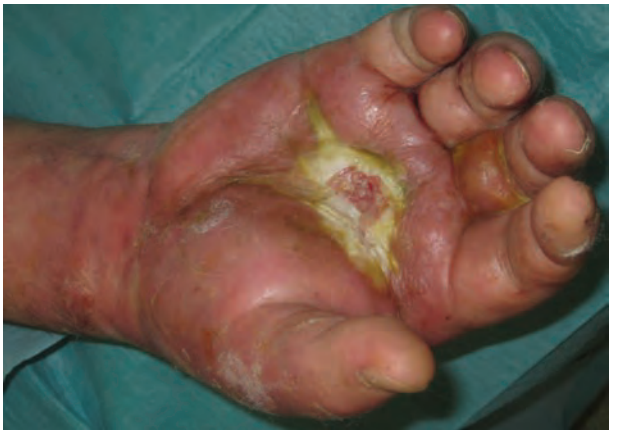

Figure 4. Septic collection (volar) at the 4th day after the first debridement.

an abundant wash with hydrogen peroxide and sodium chloride solution, we decided not to close the wound with stitches in order to facilitate the drainage of pus.

Four days later, during the dressing of the wound, we noticed a bulge in the thenar area of the right hand, compatible with a septic collection (Fig. 4). Therefore we opted for a second debridement with the excision of the whole extensor and flexor apparatus of the third ray (Fig. 5), and we sent a sample of this particulate material to the coltural exam.

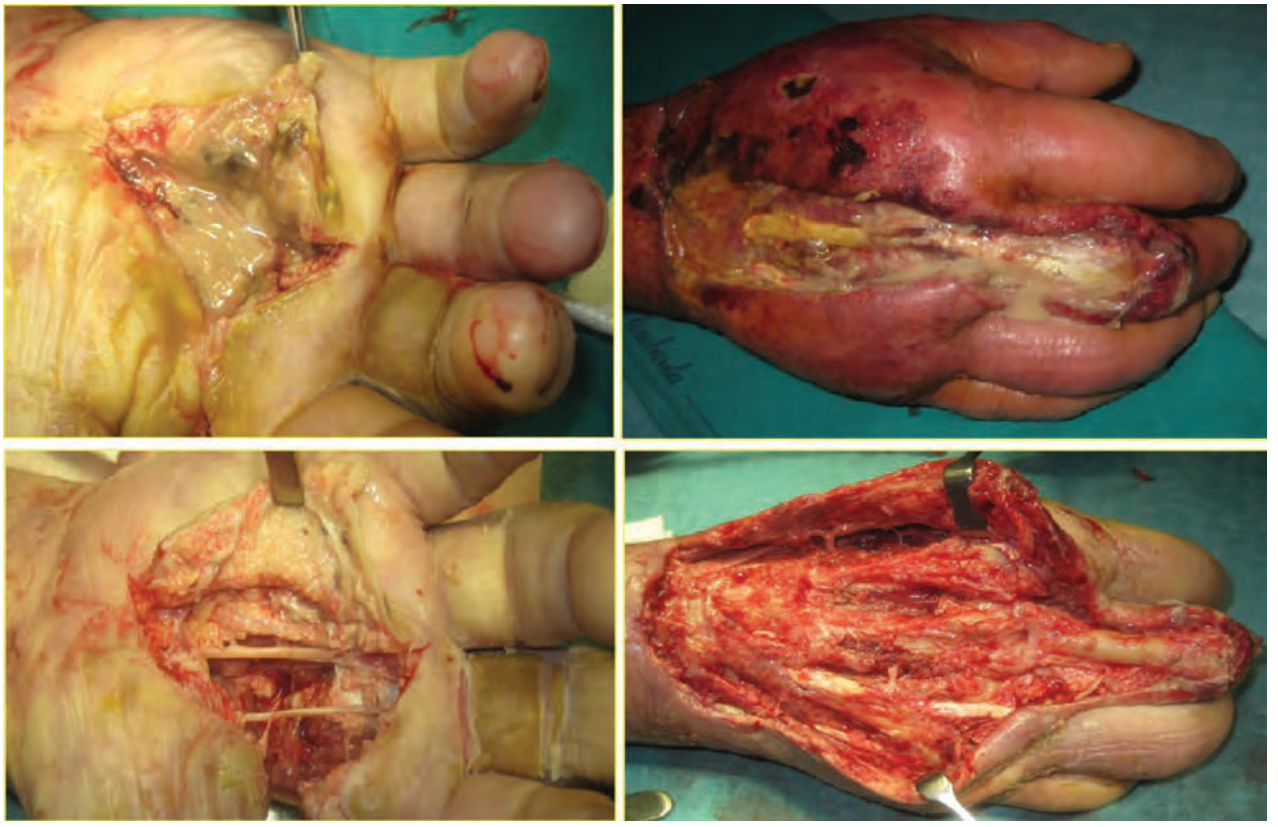

Figure 5. Intraoperative findings during the second debridement surgery and excision of the extensor and flexor apparati of the third ray

The following day, one week from the admission, we received the laboratory result from the samples collected during the first debridement, which resulted positive for Enterobacter Cloacae.

Nine days later, the samples collected during the second debridement showed a positivity for a Corynebacter, so we shifted the current EV antibiotics therpy to Teicoplanin (400 mg x 2/die) and oral ciprofloxacin (750 mg x 2/die).

At the 25th day from the admission the patient underwent the third debridement surgery.

In anticipation of a surgical procedure for the coverage of the lesion with a posterior interosseous flap (P.I.F.) we prescribed an angiography of his right upper limb; then we took the patient to the O.R. in order to amputate the third ray, whose function was severely impaired, and to perform a wedge ostectomy of the capitate and closure of the intermetacarpal space among second and fourth metacarpal bone with reabsorbable cerclages (Fig. 6). Together with these procedures we performed a coverage with a P.I.F. and a dermo-epidermic graft on the donor site (Fig. 7).

The normalization of inflammatory markers was noticed at 3 days from this last procedure; for this reason, at almost 40 days from his admission in our E.R., the patient has been released from the hospital.

At the last follow-up at 3,5 months, the patient reported a VAS of 1, and a grip strenght of 22,5 Kgs at the Jamar test (65% of the controlateral-non dominant hand) (Fig. 8).

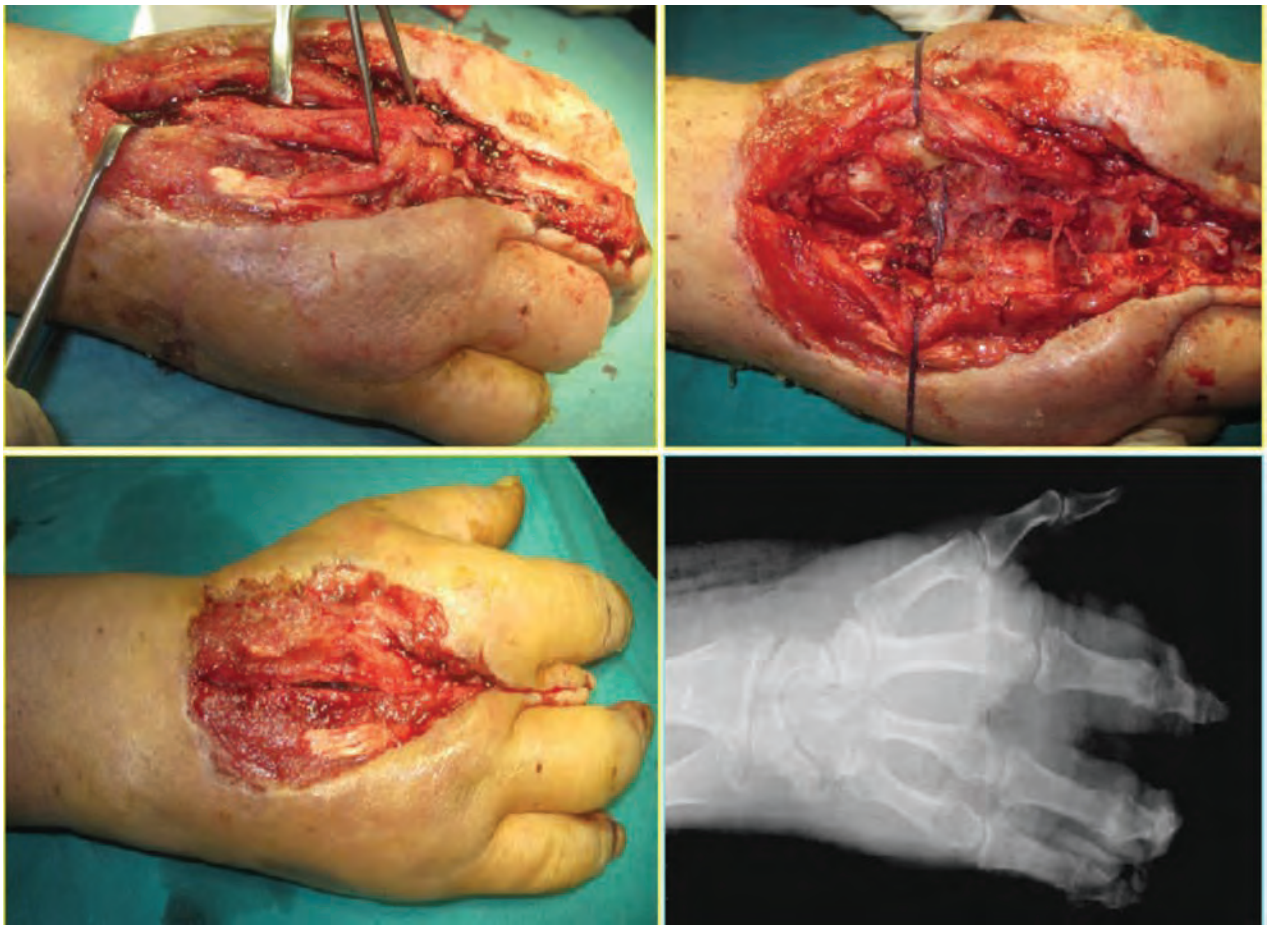

Figure 6. Sequence: isolation and excision of the third ray, capitate wedge ostectomy and closure of the corresponding web space with reabsorbable cerclages. On the lower right corner, post-op X ray

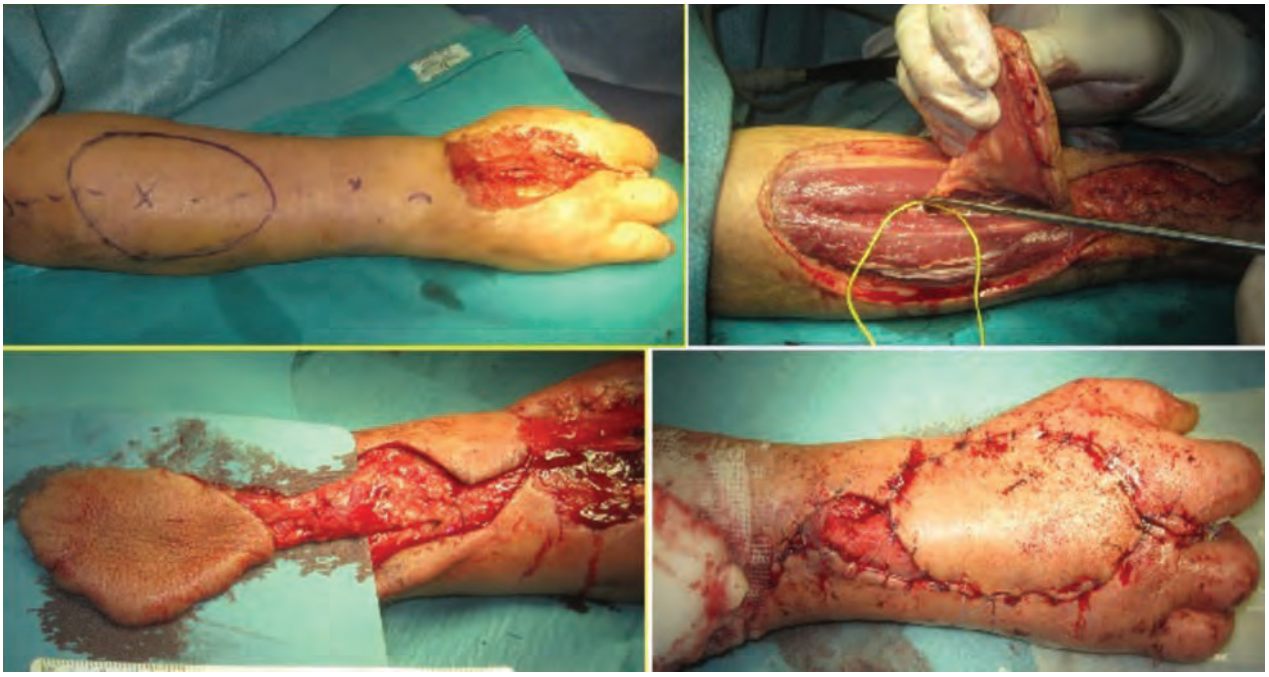

Figure 7. Sequence: skin marks, isolation of the posterior interosseous artery with a perforating vessel, and wound coverage with the posterior interosseous flap

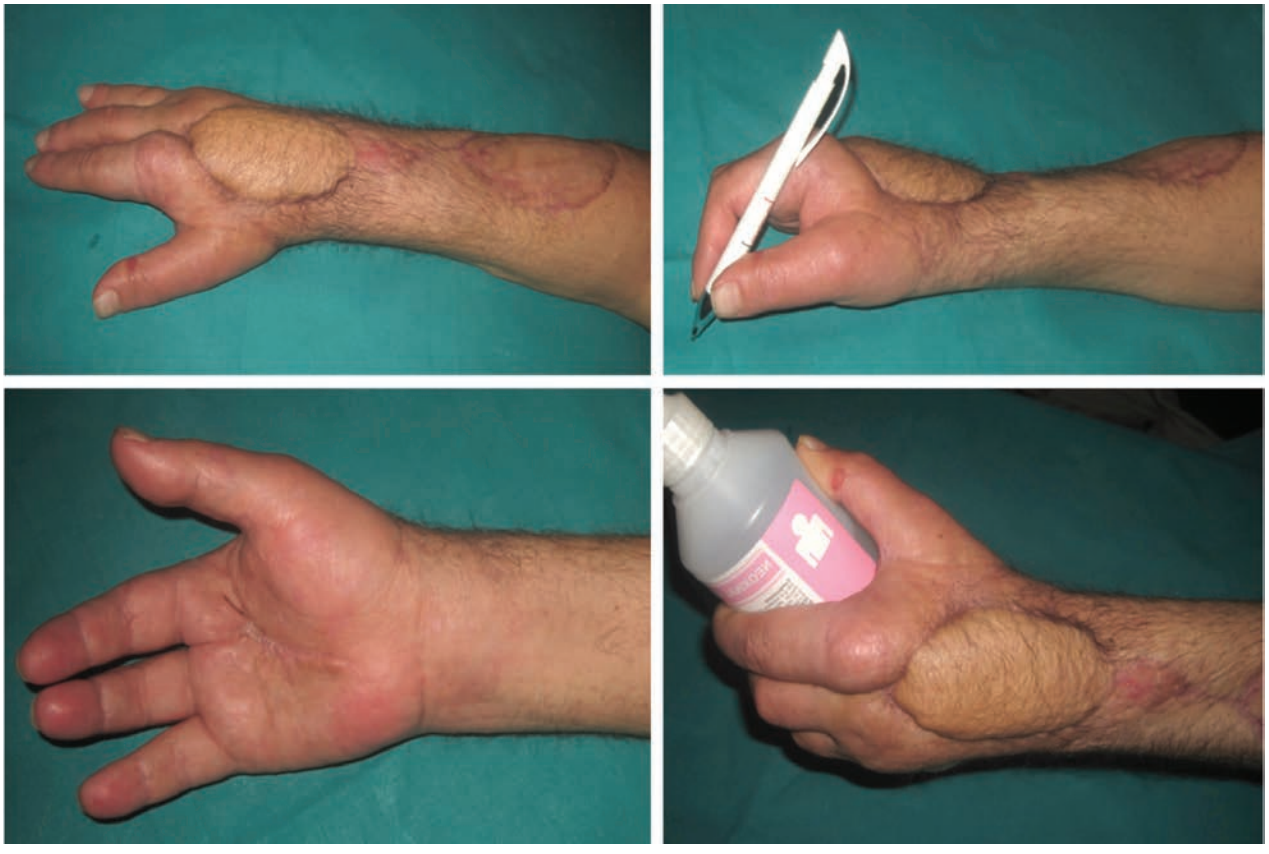

Figure 8. Last follow-up assessment at 3,5 months from the first surgery

Discussion

N.F. is a rare infectious disease, potentially lethal, usually developing on a polimycrobial aetiology, initially involving the muscular fascia and then secondarily spreading to muscular and subcutaneous tissues.

Diagnosis relies mainly on clinical findings and patient history, although laboratory and radiological findings may be a considerable support into early diagnosis of this condition.

The LRINEC score has proven to be an useful tool or the surgeon to direct the diagnosis based on clinical and laboratory parameters, although Burner et al. (16) observed an actual sensitivity of around 77%, lower than that calculated by Wong (11), in particular when used alone.

From a radiological point of view, Mc Gillicuddy et al. (17) developed a scoring system based on CT images which, by assigning scores to certain parameters (as presence of gas within the fascia -5 pts-, muscular and fascial edema -4 pts-, liquid collections – 3 pts-, lymphadenopathy -2 pts-, and subcutaneous edema -1 pt-), it allows to reach a sensitivity of 86% and specificity of 92% when the overall total score achieves more than 6 pts.

One of the crucial factors in the management of a patient affected by N.F. is time: survival rate lies approximately around 93% if the time between the admission and the first debridement does not exceed the 24 hours, decreasing dramatically to 75% at 48 hours (18).

In our case the time lapse between the indication to the first debridement and the surgery has been approximately of 26 hours; overall, time elapsed from the admission to the E.R. till the arrival in the O.R. has been around 42 hours.

International literature endorses that it takes on average 3 debridement procedures before reaching the stabilization of the clinical picture (as we noticed even in our case); amputation rate seemed to be variable between the 18% (19), the 21% (8), the 22,5% (18) and the 28% (20), although in this very last case the number of average procedures was reported to be 4.

The promptness of the debridement and his radicality have in all likelihood been the main factors that let us avoid the amputation of the patient's whole hand, limiting it just to his third ray.

The latter, deprived of the presence of flexor and extensor apparati involved by the infection, has been removed; to overcome the disability following a ray amputation (inability in small objects grasping, weakening of the grip, presence of a visible gap between the II and III ray) (21), we performed secondarily a wedge-ostectomy of the capitate (procedure initially described by Iselin and Peze (22)); tissue coverage has been reached with a posterior interosseous flap (23), and the donor site covered with an autologous mesh-skin graft taken from the thigh.

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Case report

Distal radius nonunion after epiphyseal plate fracture in a 15 years old young rider

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Summary. *Background and aim of the work:* Radius and ulna fractures are the most common long bone fractures in children and adolescents. The majority of these injuries involve the distal metaphyseal portion of the radius associated or not to physeal plate injuries. Because of the high remodelling potential of the distal radius in growing children most injuries heal without complication after closed reduction and immobilization in a long arm cast. Nonunions of closed distal radius fracture are an extremely rare occurrence especially in paediatric population. *Methods:* In this report, we describe a rare case of distal radius fracture nonunion in a 15-years old male rider treated conservatively with cast immobilization. Eight months later he underwent surgical closed reduction and fixation with kirschner wire and cannulated screw. *Results:* Follow-up at 2 years showed satisfying radiological and functional outcomes. The patient ultimately returned to ride 3 months following surgery. *Conclusions:* Nonunion is rarely seen in distal radius fractures in healthy children and adolescents, and there are few studies in the literature. Treatment of the nonunion must be individualized and the results are not entirely predictable. (www.actabiomedica.it)

Key words: non-union, distal radius, physeal plate, paediatric, adolescence

Introduction

The distal part of the forearm is the most common area to sustain a fracture in the paediatric population (1-3). Among all forearm fractures, the distal radius and ulna are most commonly affected.(4,5). Several recent studies suggest that the frequency of paediatric distal radius fractures is rising, likely due to epidemiologic trends toward diminished bone density, increased body mass indices, higher-risk activities, and younger age at the time of initial sports participation (6,7). The mechanism of injury is generally a fall on the outstretched hand and it influences fracture type and degree of displacement (5).

Signs and symptoms of these kind of fractures are pain, swelling, and deformity of the distal forearm that depend on the degree of fracture displacement.

Plain radiographs are essential in order to diagnose the lesion and to assess its classification and degree of displacement. Standard anteroposterior (AP) and lateral (LL) views usually are sufficient. CT and MRI are rarely necessary and they are reserved for evaluation of suspected or misdiagnosed intra-articular fractures or associated carpal injuries and are very useful for pre-operative planning.

Fractures of the distal forearm typically occur during skeletal development. Due to the greater forces borne and imparted to the radius, as well as the increased porosity of the distal radial metaphysis, distal radial fractures are more common than distal ulnar fractures. Physeal plate injuries of this anatomic portion are also commonly seen (8).

The Salter–Harris system is the basis for classification of physeal plate fractures (9) and in the radius type II lesions are the majority (10).

Management is highly influenced by the remodelling potential of the distal radius in growing children. Generally, these injuries are successfully treated with

nonoperative treatment. Surgery is recommended in patients with neurovascular compromise, severely displaced injuries and unstable fractures failing initial nonoperative care.

Loss of reduction and malunion are common occurrence after insufficient closed reduction and cast immobilization (11-16) but most injuries generally heal without complication after this treatment. Nonunion of closed distal radius fracture is an extremely rare occurrence and there are few studies among children and adolescent in the literature.

Case report

G.M. (15 years-old male biker) fell during a race with outstretched hand. After the fall he had pain and couldn't move the right wrist which was swollen. The patient was visited at another emergency room and conventional radiographs at right wrist were done: he reported a Salter Harris type II distal radius fracture and ulnar styloid fracture with physeal plate injury. The fractures were treated with cast immobilization for 4 weeks. After removal of cast the patient started physical rehabilitation and passive and active mobilization but he kept feeling pain and he had persistent functional limitation at the wrist. Eight months after the fall he came to our attention with pain and marked reduction of strength and movement of the wrist. An important limitation of wrist's flexion/extension and reduction of ulnar/radial deviation were observed and the patient was unable to ride. Therefore, an X-ray and CT study were performed (figures 1, 2) and nonunion of distal radius physeal plate was documented. He was operated 5 days later under plexus anaesthesia and antibiotic prophylaxis with first generation cefazolin was administered. The lesion was approached through a volar incision centred over distal radius. There was evidence of fibrous tissue interposed between radial styloid and distal radius so a cleaning of nonunion site was performed until bone fragments bleeding. Fracture was reduced with special instruments under fluoroscopy control (figure 3A and B). After bridging the gap with cancellous bone graft taken from proximal radius osteosynthesis and compression was performed with one 3 mm cannulated screw Asnis (Stryker, Mahwah, NJ, USA) and one K-wire to prevent rotations (figures 3C and 4A and B). The surgery lasted 80 minutes (tourniquet has been maintained for 60 minutes) and the patient was discharged the following day. The wrist joint was initially immobilized with plaster cast for 1 month. After the cast and k-wire has been removed, the patient started rehabilitation program with active and passive mobilizations and progressive strengthening and resistive exercises. Radiographic control performed 2 months from treatment showed bone consolidation and healing of the injury (figure 5A and B). The patient was satisfied and returned to motor race at

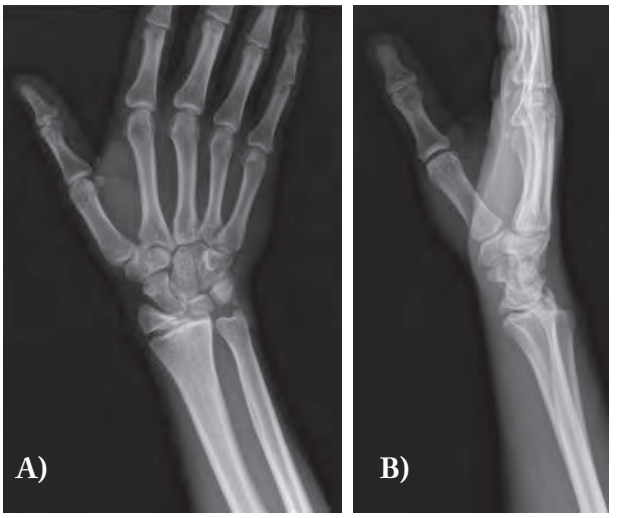

Figure 1. Preoperative X-rays (8 month after fall); AP (A) and LL views (B)

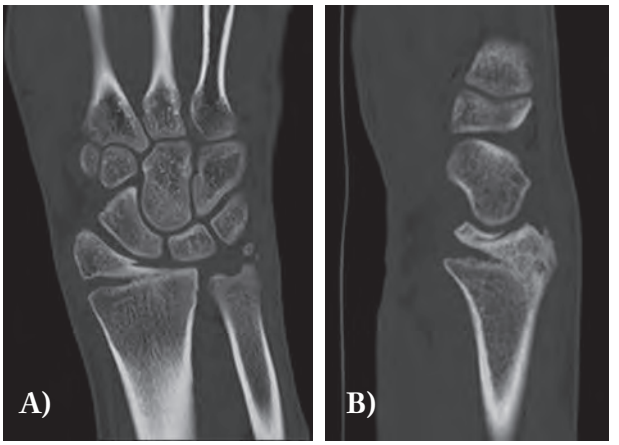

Figure 2. Preoperative CT study with physeal plate nonunion of distal radius; AP (A) and LL views (B)

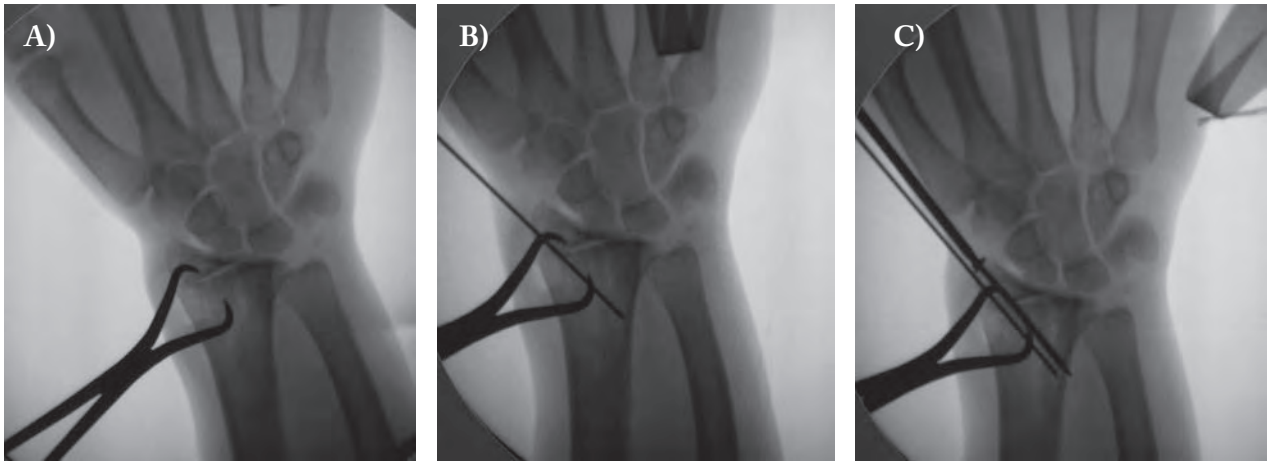

Figure 3. Intraoperative fluoroscopic controls: reduction of fracture (A); transitory stabilization with K-wire (B); definitive fixation with k-wire and compression screw (C)

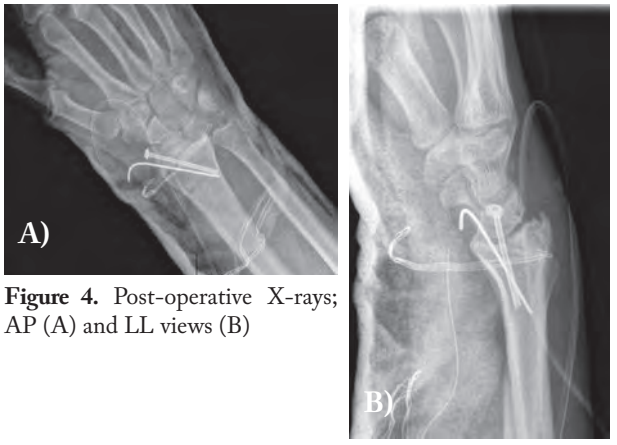

Figure 4. Post-operative X-rays; AP (A) and LL views (B)

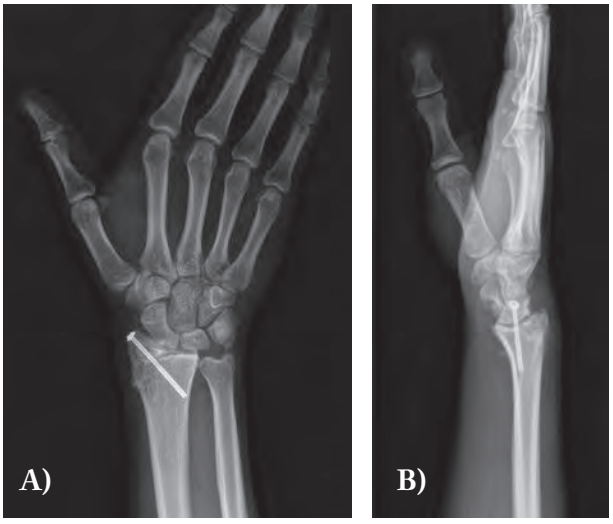

Figure 5. X-rays 2 months after surgery and removal of K-wire; AP (A) and LL views (B)

3 months from surgery. Nowadays, there are no limitations of strength and of range of motion of the right wrist and no pain has been reported (figure 6A and B).

Discussion

Distal radius fractures are the most common orthopaedic injuries that occur in the paediatric and adolescent population. Most of these lesions involves the distal metaphyseal portion of the radius but physeal plates traumas are also commonly seen, with the majority being Salter Harris type I or II fractures (17). The annual incidence of distal radius fractures has increased as a result of earlier participation in sporting activities, increased body mass index, and decreased bone mineral density (1). Distal radius fractures are more frequently sustained after a fall onto an outstretched arm that results in axial compression on the extremity or from direct trauma to the extremity. AP and LL x-ray views of the wrist usually are sufficient to diagnose a distal radius fracture. The management is based on several factors, including patient age, fracture pattern, and the amount of growth remaining. Non-

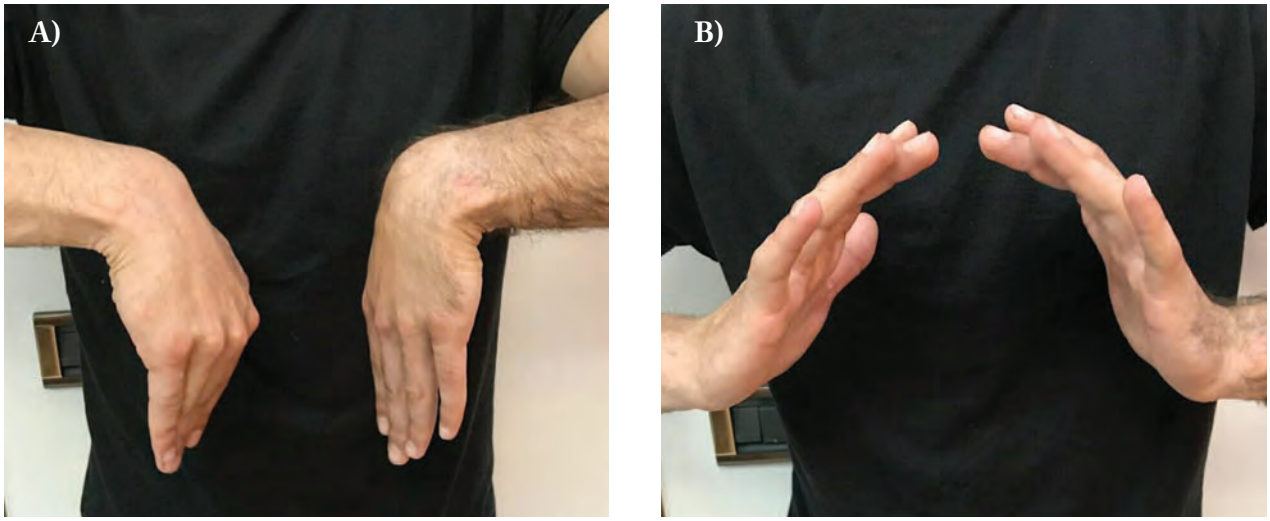

Figure 6. Clinical images 2 months after fixation with good recovery in function

surgical management is the most common treatment option for patients who have distal radius fractures because marked potential for remodelling exists. If substantial angulation or displacement is present, closed reduction manoeuvres with or without percutaneous pinning should be performed (18).

In adults pseudoarthrosis consequent to distal radius fractures is a rare occurrence but reports in the literature are present. Bacorn and Kurtzke (20) found an incidence of nonunion of 0.2%. Watson-Jones (21) reported only one nonunion out of 3199 distal radius fractures.

This type of nonunion can be observed after internal fixation, external fixation, or non-operative treatment (22) and it has been reported that comorbidities medical conditions such as diabetes, peripheral vascular disease, alcoholism, smoking and obesity may increase its risk (23-25)

An ulnar styloid fracture often occur in association with a distal radial fracture but a meta-analysis by Yuan et al. suggest that it doesn't affect the outcomes (26). In the same way Zenke et al. showed that the presence of an ulnar styloid fracture does not affect the outcome of a fracture of the distal radius which is stabilized with a volar locking plate (27).

In children, nonunion has been universally related to a pathologic condition of the bone or vascularity (10). Congenital pseudoarthrosis, neurofibromatosis, osteomyelitis and bone loss should be always suspected in a patient with a nonunion after a benign fracture (19). In paediatric fractures, nonunions have been usually reported in diaphyseal regions (28). Pseudoarthrosis following a closed radial or ulnar fracture is extremely rare and to the best of our knowledge only few reports are cited in literature in paediatric age group (29-35).

Kwa *et al*. in the first ever case reported had described a distal radius nonunion following a closed fracture in an otherwise healthy child (30). This was managed by bone grafting and casting. The factors attributed to nonunion in this report were inadequate immobilization and severe initial displacement. In two other case reports, nonunion in children had been attributed to open surgery (35), soft-tissue or vascular problems (36).

Sivashanmugam et al., focusing on pseudoarthrosis treatment, stressed the great osteogenic potential of the periosteum in children and adolescents. Their case report highlights the possibility of stimulating bony union by distracting the minimally disturbed soft tissue and thick osteogenic periosteal envelope to treat paediatric atrophic nonunion in selected patients (37). In general, in these type of patients excision of the fibrous tissue followed by compression and stabilization are sufficient in order to obtain consolidation.

Debridement of the necrotic bone and either traditional bone grafting, osteoclasis lengthening, vas-

cularised bone grafting, or creation of a single-bone forearm are surgical options and the choice depends on the individual patient (17)

Conclusions

Because of favourable local biological factors, nonunion is rarely seen in distal radius fractures in children and adolescents .

As consequence of the great osteogenic potential of the periosteum in children and adolescents, its treatment usually requires isolated excision of the fibrous tissue and internal fixation.

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Case report

Avulsion fracture of the trochanter minor in the adolescent

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Summary. In the adolescent, the trochanter minor fracture occurs in pathological traction of the iliopsoas tendon, the minor fragment dislocates cranially. The therapy is conservative, the fragment remains dislocated cranially, where it heals with the femur. A limited hip function in terms of impingement symptoms is not known. We present the case of a 14-year-old boy: the lesion occurred during sports activities (running) through hyperextension and rotation trauma. The treatment was conservative, functional limitations did not remain. (www.actabiomedica.it)

Key words: avulsion fracture trochanter minor

Introduction

In the adolescent the lesser trochanter represents the apophysis of the iliopsoas tendon attachment and has not completely fused with the rest of the femur. The avulsion fracture of the trochanter minor is caused by a pathological traction of the iliopsoas tendon. After the avulsion fracture, the minor fragment dislocates cranially. This is a rare injury; a physician will encounter almost 1-2 injuries of this type during his clinical career; the question is how to treat correctly this lesion. There are relatively few publications in the literature that describe a trochanter avulsion in adolescents. The largest case series is described by the Pediatric Hospital in Philadelphia with 36 cases in 10 years (1). All fractures occurred during sports activities. The mean age of this patient series was 13.7 years (9-17 range). Therapy was always conservative, no problems were described. Theologis describes 3 cases; in one, the fracture hasn't healed after 3 years (2).

Case description

G.J., a 14 year old boy in good clinical state. Preexisting diseases were not known. The boy presented at our department with acute pain in the left groin, occurred after sport activities (running). Trauma was hyperextension of the left hip together with rotation of the leg. Lifting up the left straigth leg caused acute pain in the groin. The passive function of the left hip was painfully limited. The x-ray of the left hip showed the avulsion fracture of the lesser trochanter (Figure 1). The trochanter minor was about 2 cm cranially dislocated. The treatment was conservative: restriction of active lifting of the leg, walking with crutches and partial weight bearing for about 4 weeks, then progressive weight bearing and full weight bearing after 2-3 weeks. X-ray exam after 1 year (Figure 2) shows: healed trochanter minor in a slightly cranial dislocated position. The patient is painless and without function restriction, he has reached the same function as before the avulsion fracture happened.

Discussion

The trochanter minor avulsions in the adolescent described in the literature occurred during sports activities. The treatment was always conservative. Limited hip function after healing of the fracture was not described. Healing of the lesser trochanter resulted in

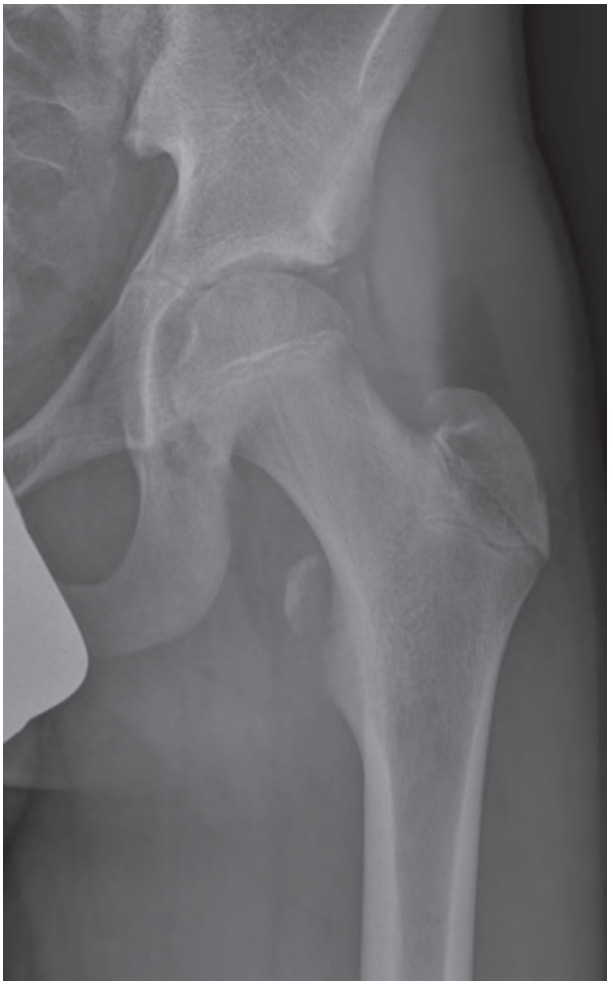

Figure 1. Avulsion fracture of the left trochanter minor, cranially dislocation

hypertrophy and fusion in a slightly cranial dislocated position (1,2). Our patient was 14 years old, the minor rupture occurred during sports due to hyperextension of the left hip during rotation. The dislocation remained at about 2 cm, the minor healed in a slightly cranial position. The treatment was conservative: protection of the left hip (partial weight bearing) and avoiding active hip flexion (starter function of the ileopsoas) for 6 weeks. After 3 months, the patient was symptom

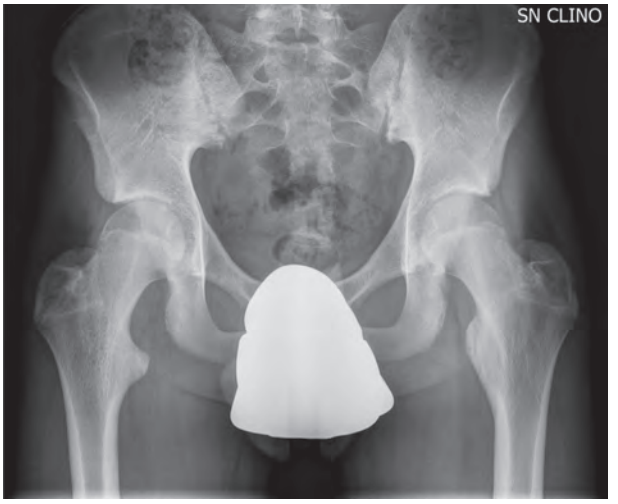

Figure 2. After healing, absence of functional limitations

free. Complaints were not observed even during sport activities, the hip function was unlimited, absence of impingement symptoms. This rare fracture heals easily conservatively in about 6-8 weeks. The slightly cranially dislocated position does not cause functional impairment of the hip. Whether the cranial displacement can lead to secondarily extra-articular impingement of the hip can not be decided so far.

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Case report

Two-stage management of a spontaneous fracture of the greater trochanter through osteolytic lesions induced by polyethylene wear of a total hip arthroplasty. A case report

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Summary. Pelvic osteolysis induced by particulate debris derived from bearing surfaces is a well-known complication following total hip arthroplasty (THA). Atraumatic fractures of the greater trochanter (GT) associated with osteolytic lesions have been occasionally described. We present a case of a 71-year-old male patient who sustained an undisplaced fracture of the GT nine years following cementless metal-on-polyethylene THA. The fracture occurred through a 2.5-cm large osteolytic area, and no hip trauma was recorded. Conventional radiographs revealed peculiar signs of massive wear of the polyethylene acetabular liner (marked eccentricity of the prosthetic head and extensive osteolysis around the iliac screws), allowing to immediately conclude about the benign nature of the pathological fracture. To our knowledge, a two-stage management, planning conservative healing of the fracture and subsequent surgical replacement of the worn acetabular liner, has never been previously detailed. (www.actabiomedica.it)

Key words: total hip arthroplasty, trochanteric fracture, osteolytic lesion, periprosthetic fracture, pathological fracture, polyethylene wear

Introduction

Pelvic osteolysis is a well-known complication following total hip arthroplasty (THA) (1). It has been attributed as the biological response to wear debris of several materials, but polyethylene (PE) particles are the most implicated agents (2-4). The occurrence of a spontaneous fracture of the greater trochanter (GT) has been rarely described as a complication of particulate PE debris (5-10). In the reported case, a two-stage management, including conservative healing of the fracture and subsequent surgical exchange of the worn acetabular liner, was immediately planned and successfully performed.

Case Report

On September 2008, a 71-year-old male with a BMI of 33.4 presented to the First Aid of our Hospital with complaints of a severe pain over the lateral aspect of the left hip and inability to bear weight. In 1999 the patient underwent primary cementless THA with metal-on-polyethylene bearing for avascular necrosis of his left femoral head; the contralateral hip had been replaced in 1996. The acetabular component was a 58-mm PCA, hydroxylapatite-coated hemispheric cup (two cancellous screws were used to supplement the primary stability) fitted with an Ultra-High-Molecular-Weight Polyethylene elevated rim liner. The femoral component was a Citation anatomical stem size 3 that accepted a 32-mm diameter, +4 mm long cobalt-chromium alloy (CrCo) head (Howmedica, Rutherford, New Jersey, USA). Both stem and socket were made of a cobalt-chromium alloy (Figure 1). The postoperative course was uncomplicated, and the patient had a complete functional recovery. Since he was asymptomatic, he declined routine follow-up radiographic checks up to April 2007, when x-ray dem-

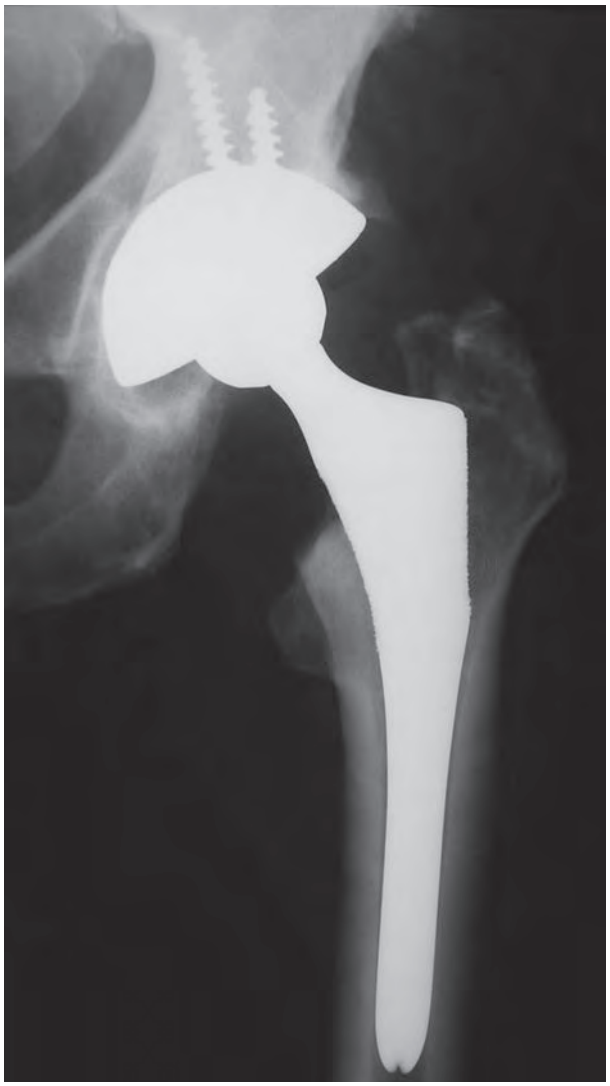

Figure 1. Immediate postoperative x-ray shows the correct positioning of a left cementless total hip arthroplasty

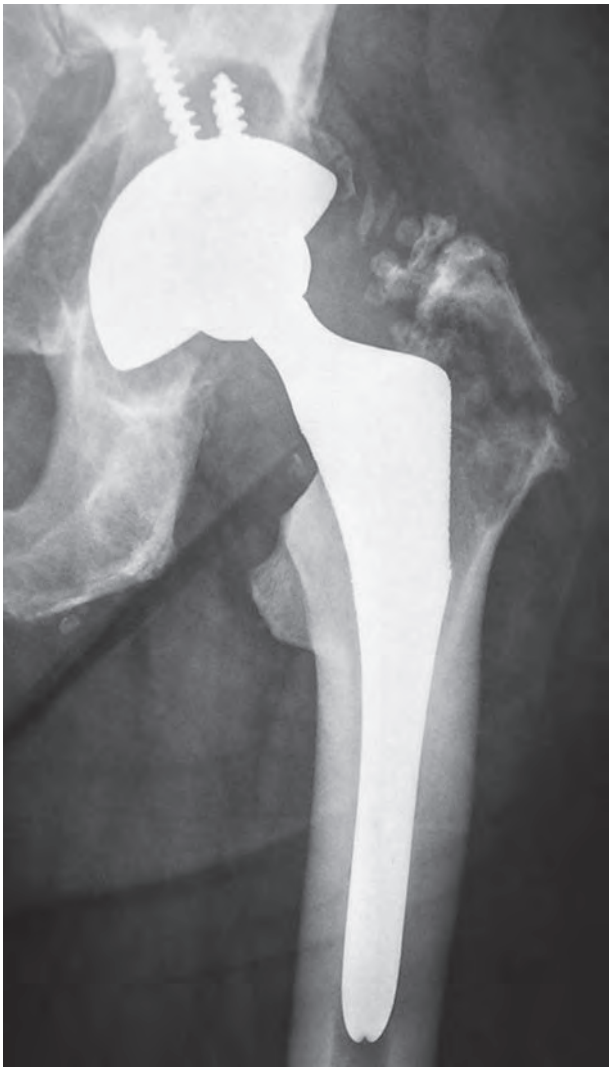

Figure 2. Emergency radiograph obtained at acute onset of pain documents an undisplaced fracture through a cystic lesion in the greater trochanter. Pelvic osteolysis around acetabular screws and eccentric polyethylene wear are evident

onstrated the occurrence of osteolysis behind the acetabular metal shell, which was not responsible for any pain or hip impairment. Nine years following surgery (September 2008) the patient experienced sudden onset of acute pain. Pain developed after a normal extension movement of the hip joint, and no previous trauma had been recorded. Physical examination revealed an intense tenderness over the trochanteric area. Conventional radiographs showed an undisplaced fracture of the greater trochanter and a 2.5-cm large osteolytic area behind the acetabular shell around the two iliac screws (Figure 2). Though there were no signs of loosening of the metal PCA cup, a marked asymmetric position of the prosthetic head could be detected, revealing eccentric wear of the acetabular polyethylene liner. A two-stage management of the pathological fracture was planned. Given the minimal displacement of the greater trochanter, conservative healing of the fracture was pursued. Consequently, the patient was treated with an abduction brace and pain-limited weight-bearing on the affected limb for four weeks, then he progressed to partial weight-bearing for another four weeks. At 6-week x-ray follow-up, significant signs of

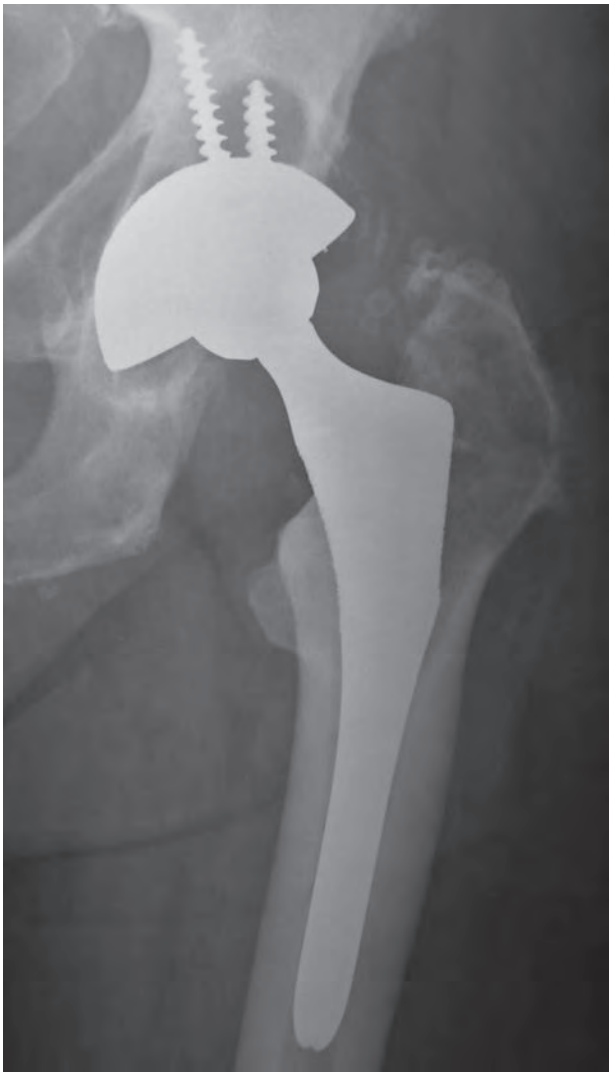

Figure 3. Six-week x-ray check demonstrates significant signs of fracture healing

fracture healing were present (Figure 3). Subsequent computed tomography scan confirmed that fracture of the GT had healed, revealing extended areas of acetabular bone deficiency (Figure 4).

On March 2009, six months after the occurrence of the fracture, revision surgery was performed via an anterolateral approach to address the cause of osteolysis. On arthrotomy both acetabular metal shell and femoral stem were well fixed to the bone, but erosion of approximately one third of the peripheral polyethylene rim was found. The greater trochanter appeared to be definitely healed. A small fragment was obtained

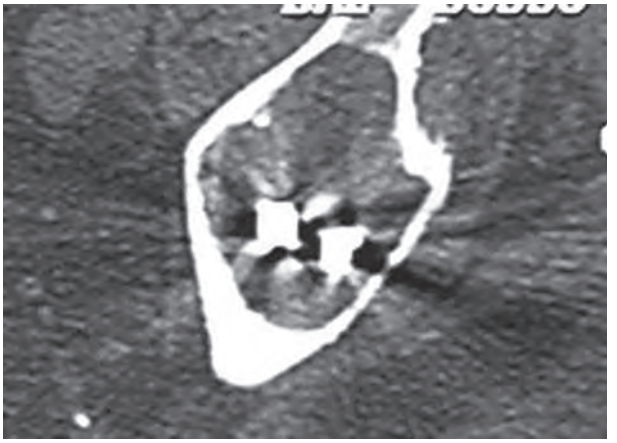

Figure 4. Computed Tomography taken two months after the fracture. Reveals extended areas of acetabular osteolysis

from the tip of the GT and the histological study showed the presence of a vigorous remodelling bone tissue consistent with a normal fracture healing process (Figures 5a and 5b). Revision included removal of both screws, which were completely loose, and filling pelvic defects with morselized bone allograft through the screw holes of the metal-back cup. Finally, brand new coupling surfaces (PE liner and CrCo prosthetic head) were implanted (Figure 6).

At the most recent follow up examination, five years after revision surgery, the patient has resumed all his activities of daily living with no hip pain and successful radiological outcome (Figure 7).

Discussion

Osteolysis associated with particulate debris from the bearing surfaces is a common long-term complication of hip replacement surgery (1). Prosthetic wear debris, expecially derived from polyethylene (3, 11), activate macrophages and osteoclasts, promoting bone resorption (2, 4, 12). Extensive bone loss occasionally may lead to pathological periprosthetic fractures, usually around well-fixed implants (5-10). Bone loss frequently courses symptom-free, even for several years (13). Therefore, most orthopaedic surgeons recommend periodic clinical and radiographic monitoring of prosthetic implants assessing signs and symptoms of osteolysis as well as of loosening (7, 14).

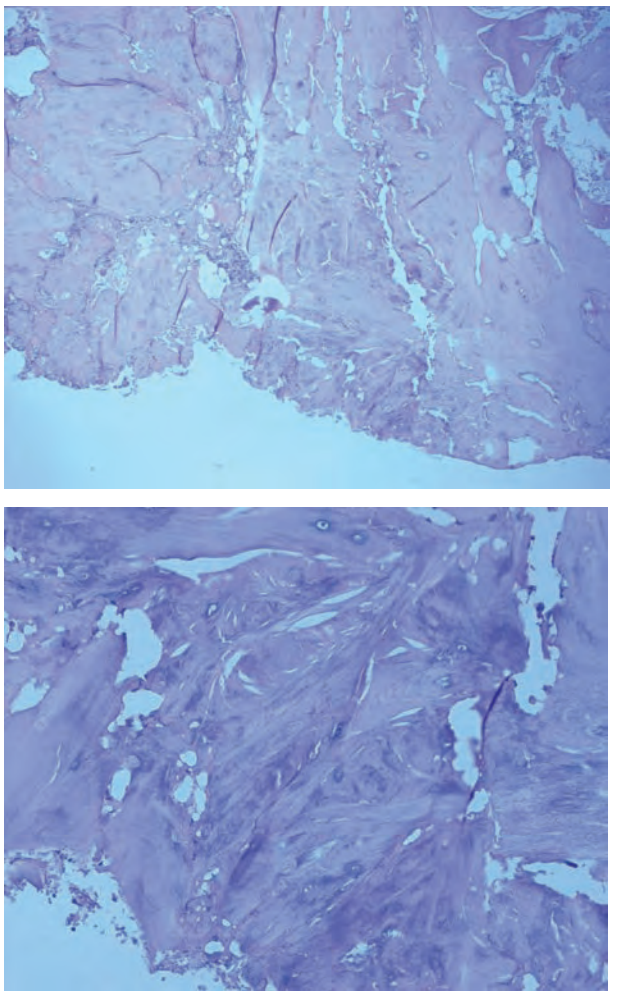

Figure 5. Histopathological findings. (a) Low power view (x40) showing acellular (necrotic) tissue and woven bone in the greater trochanter, which is indicative of a reparative process. (b) The same bone fragment at high magnification (x400) shows woven tissue

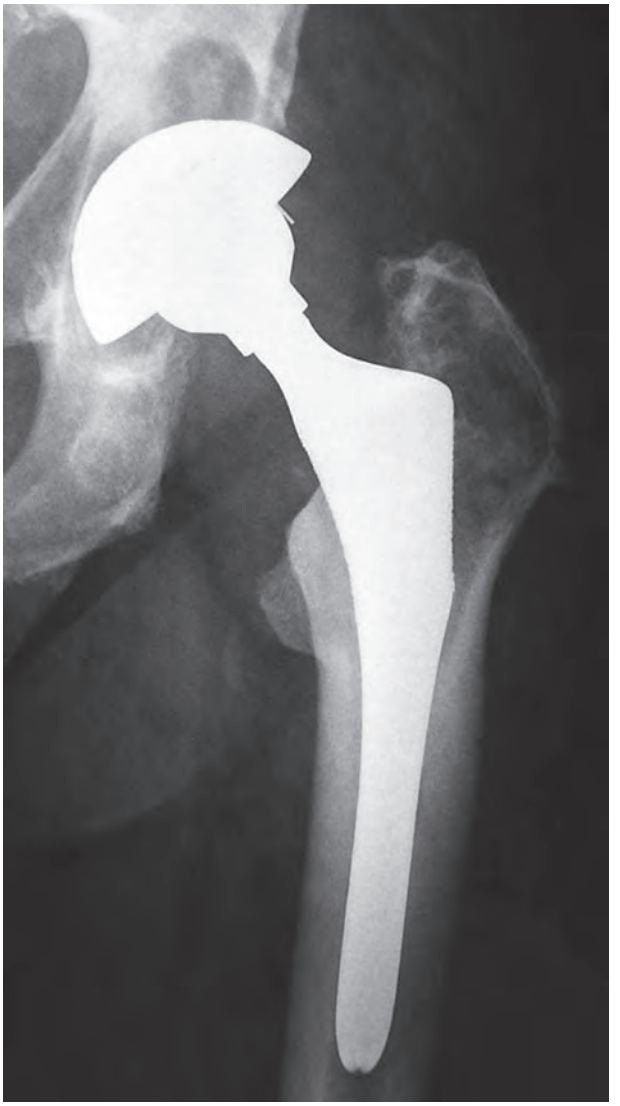

Figure 6. Postoperative radiograph. Iliac screws were removed and acetabular bone defect was partially filled with morselized allograft; both prosthetic bearing surfaces were replaced

Spontaneous fractures of the GT through cystic lesions are a late complication of THA, typically presenting with sudden onset of pain in younger and active patients with high activity levels several years after surgery (5, 6-8).

Whether markedly displaced acute fractures of the greater trochanter require immediate wire fixation and allogeneic bone-grafting to fill osteolytic defects (9) or plate osteosynthesis (15), lesions with minimal displacement can undergo nonoperative treatment successfully with an abduction orthosis and limited weight-bearing, leading to bone healing within three months (7). However, the fracture indicates the presence of a significant wear problem. Claus et al. reported that, although the fractures of the GT with minimal displacement healed without the need for surgical stabilization, the size of the osteolytic lesions increased (6). Consequently, osteolysis of the GT secondary to excessive PE wear ultimately requires surgical treatment to address the underlying problem of particulate debris generation promoting periprosthetic bone loss. Immediate curettage and grafting of the trochanteric cyst and simultaneous exchange of the worn acetabular liner has been reported in two patients by Heekin et al. (5).

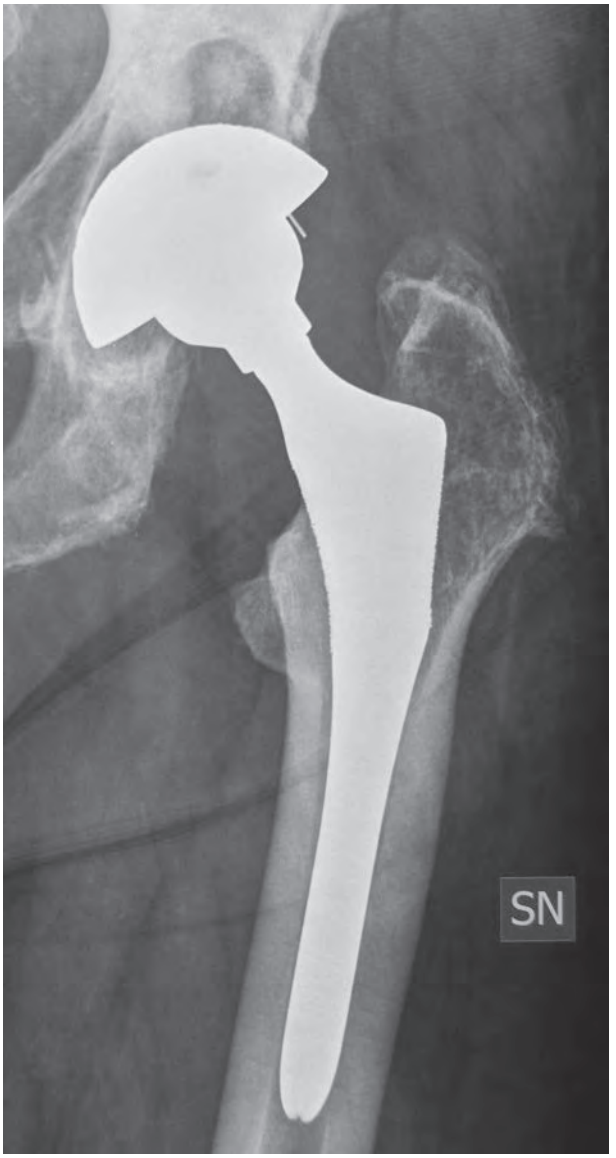

Figure 7. Conventional x-ray performed five years following revision surgery shows complete healing of the trochanteric fracture with periprosthetic bone stock restoration

The greater trochanter is a frequent area for osteolysis because a large cancellous bone surface is in close proximity to the usual source of particle production, the bearing surfaces. Unfortunately, osteolytic lesions of the GT commonly occur in asymptomatic hips and can be difficult to see until they become larger (7). Brown and Ring described 7 cases of bone resorption and trochanteric separation in a small series of 10 hips with extensive osteolysis in the proximal femur which were assessed up to nine years postoperatively (16). Hence, x-ray appearance of resorptive changes should be regarded as an impending pathological fracture.

In the reported case, the patient did not have a history of trauma, and the prosthesis performed well clinically. At the latest follow-up (April 2007), although pelvic osteolysis had been clearly detected, the hip was found to be well-functioning and painless. After a few months of hip bracing and restricted weight-bearing, which facilitated fracture healing, delayed revision surgery could be undertaken to reduce particle generation (7).

In conclusion, the occurrence of a spontaneous fracture of the greater trochanter associated with THA is an unusual presentation of polyethylene wear debris and related bone resorption (5-9). Undisplaced lesions can be successfully treated with a two-stage approach, including conservative healing of the fracture and subsequent surgical replacement of the acetabular liner, thus addressing the underlying problem of wear.

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Case report

Asymmetric bilateral hip dislocation in young man: a case report

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Summary. Bilateral hip dislocation is a rare event, asymmetric dislocation is even rarer. Due to the intrinsic stability of the hip joint this lesions usually follow a high energy trauma. Because of the common associated lesions, the initial clinical assessment should be performed thoroughly. CT scan rather than x-rays offers a complete survey of these possible associated injuries such as thoracic or abdominal bleedings, neurologic lesions or fractures directly associated with the hips dislocations. The first goal should be reduction of the dislocation to prevent avascular necrosis (AVN) of the femoral head and arthritis. We report a case of a young man with right anterior hip dislocation and left posterior hip dislocation with associated fracture of the posterior wall. (www.actabiomedica.it)

Key words: asymmetrical hip dislocation, traumatic hip dislocation, bilateral dislocation

Introduction

Usually hip dislocations occur after traumatic injury and 85-90% of these are posterior dislocations (1). Bilateral dislocations account for 1% of all hip dislocations (2). In the English-language literature only 29 documented cases of this dislocation pattern can be found (3-9).

Case report

A 23 year-old male had a car accident at approximately 70 km/h. He was brought at the emergency department (E.D.) within 2 hours after the accident. At the arrival he was hemodynamically stable but with a GCS=3. He reported several abrasions all over the body and had evident deformations of both lower extremities. The left hip was shortened, adducted and internally rotated, the other one was shortened, abducted, externally rotated and flexed at 30°. Both the extremities had limited range of motion (the former limited external rotation, the latter limited internal rotation). The lower limbs were warm and the peripheral pulses were strong and symmetrical.

Initial imaging included computer tomography (CT) of brain, thorax, abdomen and pelvis.

CTs were negative for hemorrhages but revealed a fracture of the left clavicle and an asymmetric bilateral hip dislocation.

The right hip was anteriorly dislocated with no associated fractures. The left hip was posteriorly dislocated with a fracture of the posterior wall (Fig. 1)

The right hip was successfully reduced in the E.D. whereas the left one couldn't be reduced with external maneuvers (Fig. 2). In the following days the patient was diagnosed with diffuse axonal injury with a series of encephalic CT scans.

In consequence of the neurological condition the left hip was surgically reduced and the fracture of the left pelvis fixed fifteen days later together with the clavicle fracture. The posterior wall fracture was fixed with two plates using a posterior approach.

A new pelvis radiograph showed the good outcome of the operation (Fig. 3).

On a pelvis radiograph taken 6 months after the

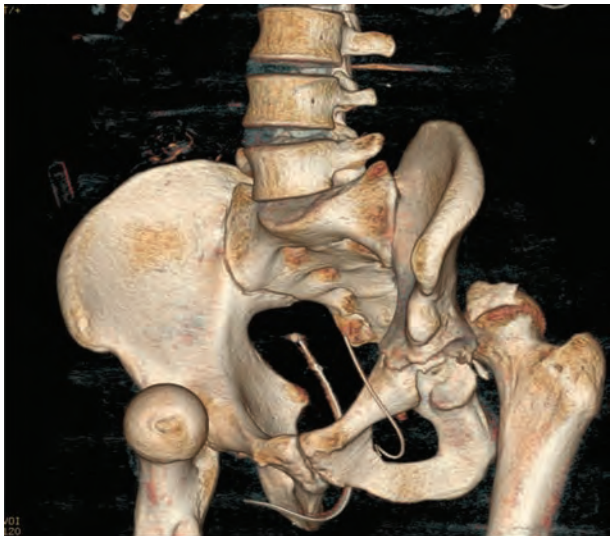

Figure 1. Preoperative TC

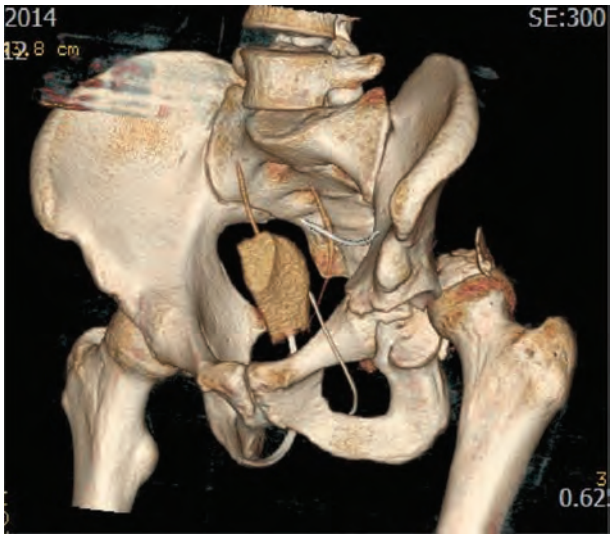

Figure 2. TC after reduction Right Hip

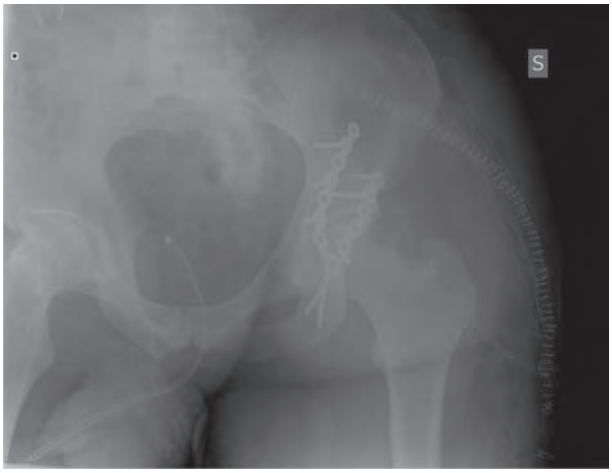

Figure 3. Post-op x-rays

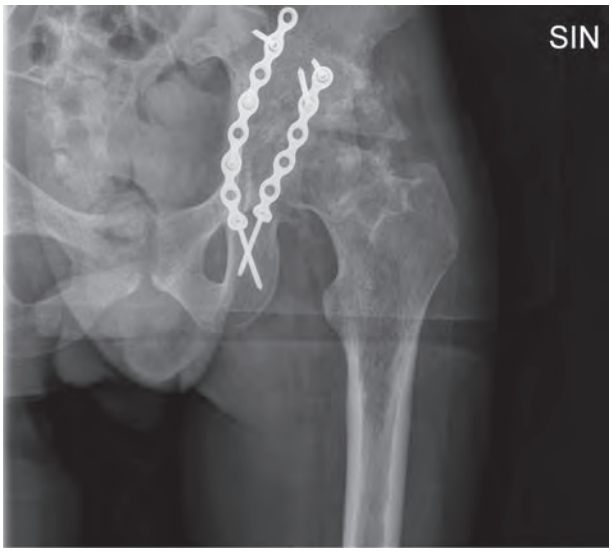

Figure 4. Six months follow up x-rays

accident the right hip showed no pathological signs whereas the left one showed signs of necrosis of the femoral head (Fig. 4). Because of the neurological situation a clinical assessment could not be performed.

Discussion

Due to the intrinsic stability of the hip joint this type of lesions are usually caused by a high energy trauma such as a car or motorbike accident (10-14).

The hip joint bases his stability on different elements like the depth of the acetabulum increased by the labrum, a thick capsule and a strong group of muscles. There's also an efficient ligamentous system represented by the capsular ligaments and the teres ligament.

Usually these types of lesions are caused by a dashboard injury (15). A crash with an abducted hip leads to an anterior dislocation whereas an impact with an adducted hip cause a posterior dislocation (16, 17-19).

Associated injuries are always to be looked for carefully. They include femoral fractures (shaft, neck, heads), pelvis and acetabular fractures, fractures of knee, ankle and foot (20-22).

Abdominal, chest and head injuries are also reported to be associated with hip dislocations (22-25), similar to our patient who reported a diffuse axonal injury and a fracture of the left clavicle.

Clinical examination is the most important element to diagnose a hip dislocation.

In a posterior dislocation the hip is internally rotated, flexed and adducted whereas in an anterior dislocation the hip is externally rotated and abducted. A plain radiography of the pelvis is enough to confirm the diagnosis but with a computed tomography associated fractures can be fully examined.

The reduction of the dislocation must be performed as soon as possible to prevent complications such as avascular necrosis (AVN) the incidence of which increases if the reduction is delayed (23).

A closed reduction should always be the first choice unless there are associated hip or pelvis fractures.

A surgical approach is chosen in cases of irreducible dislocation or non concentric reductions.

Usually in posterior dislocations a Kocher-Langenbach approach is used, anterior dislocations are addressed with an anterior or antero-lateral approach (26). In addition to provide a concentric a stable reduction is important to remove intra-articular bone or cartilage fragments that interpose between the articular surfaces. An arthroscopic approach can be used if the only aim is to remove little fragments without fixing them. After closed reduction weight bearing should be avoided for only 2 weeks starting mobilization as soon as the pain permits (27).

Hip mobilization should be started immediately and weight bearing allowed after 6-8 weeks.

Poorer outcomes are associated with posterior dislocations, associated injuries and a delayed time of reduction (>6 hours) (1, 28-30).

All these elements may have an effect in causing AVN and arthritis which are associated to poor clinical outcomes.

Conclusions

In the case reported the right hip was treated early with closed reduction and at 6 months x-rays shows no pathological signs, for the left one an open reduction and internal fixation were performed after fifteen days because of major neurological problems and at 6 months x-rays shows clear signs of AVN. The time of reduction and the associate lesions could explain the different outcome between the two hips.

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Case report

Bent femoral intramedullary nail: a case report and review of the literature

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Summary. Intramedullary nailing is considered the gold standard technique for the treatment of femoral shaft fractures. A rare complication of this technique is nail bending after a new trauma. In these cases nail removal might be really challenging. The present paper provides a brief review of surgical techniques purposed in the literature for bent nail removal and describes a clinical case. (www.actabiomedica.it)

Key words: bent intramedullary nail, femoral shaft fracture, bent femoral nail, bent nail removal

Introduction

Intramedullary nailing is considered the gold standard technique for the treatment of femoral shaft fractures (1). In rare cases, a second trauma to the femoral shaft might lead to nail bending, which may be associated to a new fracture or displacement of the primary unhealed fracture. A bent nail is more difficult to remove in comparison to a broken one, because of the impossibility to pass the straight proximal intramedullary canal. In these difficult cases key factors for treatment planning are the degree of angulation of the nail, the direction of the deformity, the location of the deformity, patient local and general conditions and surgeon experience. Since the rarity of the pathology there is no widely accepted algorithm for the removal of a bent femoral nail (2). On the other hand, some literature issues regarding technical aspects and treatment proposals can be retrieved. Furthermore, definitive treatment of the fracture after nail removal may still deserve a discussion. The present paper provides a brief review of surgical techniques purposed in the literature for bent nail removal and describes a clinical case.

Bent nail removal: surgical techniques

Standard removal of a bent nail as a straight nail is described by different authors (2, 3). The advantage of this surgery is soft tissue preservation and no need for special equipment. The feasibility of this technique depends on the stiffness of the nail and the degree of deformity. Therefore, indications for this technique are in case of 15-20° of nail deformity, thin titanium nails, simple fracture and anterolateral deformity. Different authors have reported this technique as successful (2, 3).

Patterson et al. described the technique of closed straightening using a perineal post as fulcrum associated with external maneuvers and internal removal without opening the fracture site for nail resection (4). However, this technique is difficult to perform in case of antero-posterior angulation. In this cases Haffernan et al. advised the use of F® (Synthes West Chester, PA) tool for manual reduction of long bones. On the other hand, in case of thick nails the excessive force required may produce soft tissue injury and secondary fractures (5). The site of deformity location too proximal or too distal requires higher forces for reduction and is more predisposed to iatrogenic injuries. Beck et al. reported a secondary fracture during attempts of deformity reduction in such a case (6).

The most commonly used technique is partial weakening at the apex of the deformity of the nail and manual straightening. Location of the apex of nail deformity is the key factor for this technique. In case of valgus deformity indeed exposure of the medially

oriented apex may be surgically risky and demanding (7, 8). Percutaneous partial weakening technique at the apex of nail deformity using a drill bit has also been described. This technique has the advantage of being soft tissue sparing while the disadvantage of difficult metal debris irrigation and fluoroscopy dependency (9).

The total cutting at the deformity apex of the bent nail requires open technique and adequate instruments to cut the nail (10, 11). Total cutting of the nail and removal of the parts requires no force application for the reduction of the nail deformity thus reducing the risk of secondary fracture. This technique has the obvious disadvantage of greater soft tissues invasiveness while the advantage of low device demand and limited use of fluoroscopy. Furthermore, the use of continuous irrigation at the cutting site decreases the risk of tissue necrosis, nonunion and infection. The approach can be used both for nail cutting, anatomic bone reduction and fracture osteosynthesis as the apex of the deformity usually corresponds to the fracture site.

Cases when nail removal is not feasible even after nail cutting are reported in literature. In such cases the nail is usually stuck in the femoral canal, thus approach extension for longitudinal bone window opening should be considered as an option. A rectangular bone window and total nail exposure is necessary. The nail is extracted from this window in the proximal part and if not totally resected could be twisted for an easier extraction of the distal part of the nail. The bone window should then be fixed with cables or plate osteosynthesis. Nonetheless, wider soft tissue dissection to obtain an adequate bone window may lead to major complications (12). The main limitation of this technique is that in case of valgus deformity a medial femoral shaft approach might be necessary.

Another option for straightening the nail has been described using a broad plate and reduction clamps. The nail is straightened progressively using the forceps to gradually compress the shaft against the plate under fluoroscopy control (13). In cases of severe deformity and osteoporosis this technique should be used with caution due to high risk of secondary fracture. Successful application of this technique through a minimally invasive approach has been described by some authors (14).

Case report

A 19 years old man was admitted to our hospital after a high energy motorcycle accident in February 2018. The patient presented with a severe varus deformity of the left thigh and an ipsilateral open fracture of the distal femur, without neurovascular injuries. Associated injuries were a left wrist trans-scaphoid trans-styloid perilunate fracture-dislocation and a right occipital condyle fracture. The patient height was 1,95 m and weight 115 kg. The patient had a previous motorcycle accident with a femoral diaphyseal fracture treated with an antegrade T2 Recon nail (Stryker™) almost 2 years before the recent trauma. Anamnestic data revealed full weight bearing without aids and full return to everyday life at the latest follow-up outpatient evaluation (18 months after surgery). However, the patient referred dull pain at the fracture site at weight bearing, with radiographic signs suspect for hypertrophic nonunion (Figure 1). Plain radiographs obtained at the emergency department showed a refracture of the femoral shaft in correspondence to the nonunion site with 145° nail angulation in the coronal plane. The distal locking screws were also bent (Figure 2). A comminuted fracture of the distal femur (AO type 33 C3) was confirmed, occurring at the tip of the previously implanted nail. The patient was treated in the first hours with a damage control procedure. An external fixator bridging

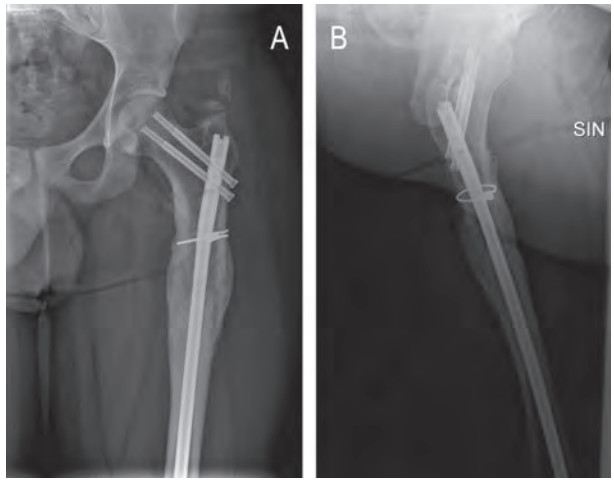

Figure 1. Eighteen months follow-up radiographs after intramedullary nailing for proximal third diaphyseal femur fracture, showing a possible hypertophic nonunion A) AP view B) Lateral view

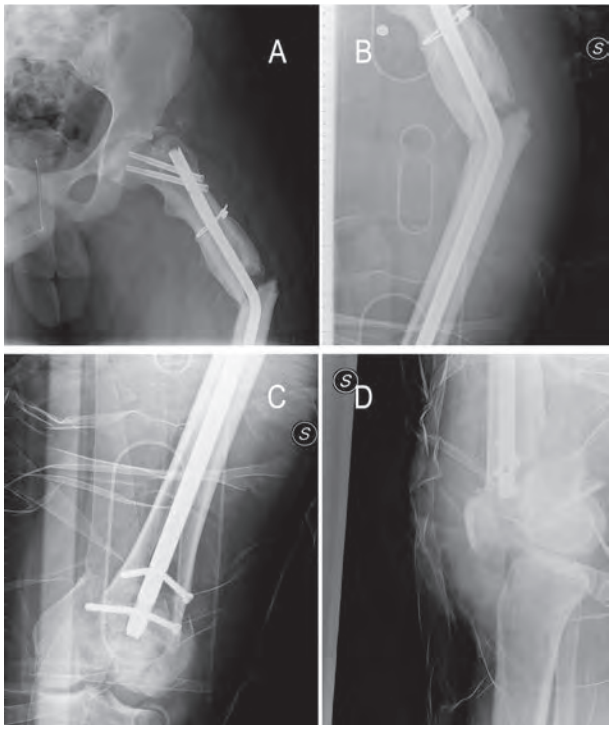

Figure 2. Plain radiographs obtained at the emergency department, showing a new fracture occurring at the nonunion site with 145° nail angulation in the coronal plane (A, B). A complex articular distal femur fracture was associated, with nail distal locking screws bending (C: AP view; D: Lateral view)

the knee joint was applied in order to gain length, axis and rotation at the distal femur fracture site (Figure 3). Accurate debridement of the open fracture was carried out, classifying the lesion as Gustilo (15) type II open fracture after the procedure. Primary closure of soft tissue was achieved. After surgery the patient was kept under observation for three days in intensive care unit and transferred to our orthopedics and traumatology unit afterwards. Definitive treatment was scheduled on the seventh day after trauma.

Surgical technique

Under general anesthesia, the patient was positioned supine on the fracture table and previously implanted external fixator left in place. The injured limb was prepped and draped. Manual straightening of the nail was attempted under fluoroscopy control without success. Under fluoroscopy the apex of the bent

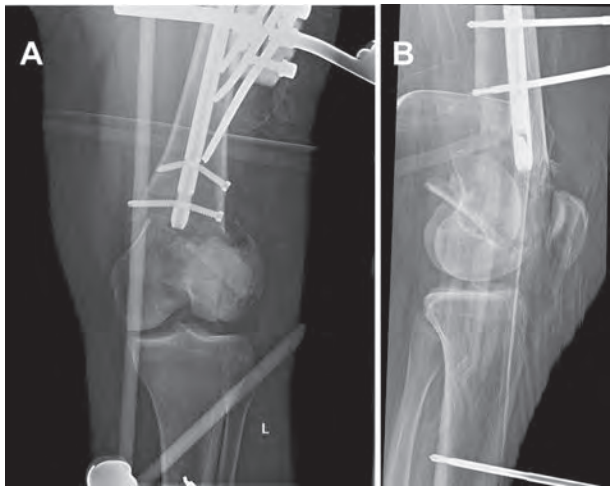

Figure 3. Post-operative radiographs of the distal femur showing fracture alignment after bridging external fixator application. A) AP view. B) Lateral view

nail was identified. A limited lateral approach to the femur over the fracture deformity was performed. A small cortical bone window over the apex of the nail deformity was necessary to expose the nail for milling (Figure 4). The nail was resected with diamond burrs until easy rupture was obtained at the apex of the deformity. Continuous irrigation and suction were used for tissue cooling and metal debris removal (Figure 5).

Lateral approach to the proximal femur was used for the removal of the proximal part of the ruptured nail after removal of the 2 cephalic blocking screws. The distal part was removed from the diaphyseal fracture site after removal of the distal blocking screws.

Under fluoroscopy the diaphyseal fracture was stabilized with stainless steel cerclage and definitively fixed with a 11x340 mm T2 Recon Stryker™ nail in static configuration. Two suction drainage were positioned during wound closure.

New sterile prepping and draping was used for the osteosynthesis of the complex articular distal femoral fracture after removal of the external fixator. Lateral approach to the distal femur was performed, with distal extension through a tibial tubercle osteotomy to obtain adequate exposure.

The fracture was reduced and definitively fixed with a Zimmer™ NCB distal femoral plate. Morcellized trabecular bone allograft was used to treat metaphyseal bone loss. The tibial tubercle was fixed with

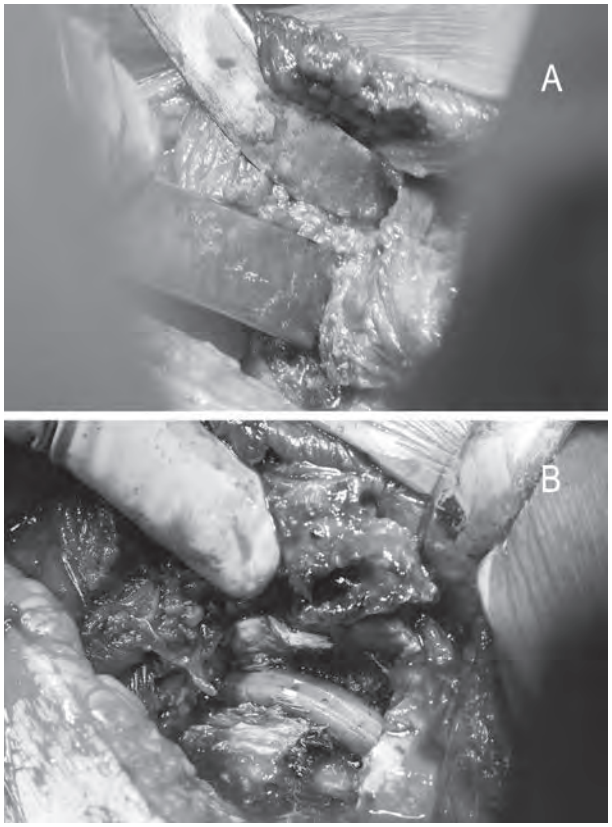

Figure 4. Intraoperative photographs. A) Apex of bone deformity is exposed after lateral access to the femur. A bone window on the fracture is being opened with an osteotome. B) Apex of the bent nail deformity is visible after bone window opening

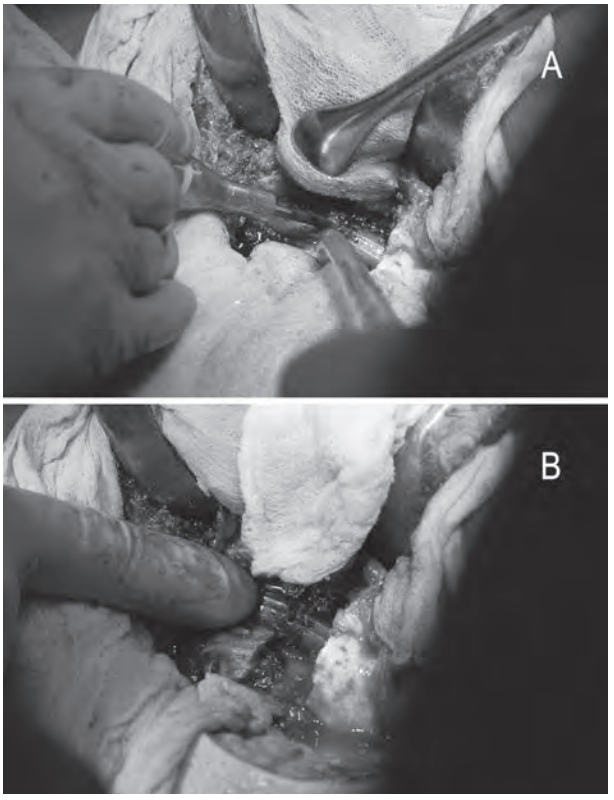

Figure 5. Intraoperative photographs. A) Milling of the bent nail apex with diamond burrs. Gauzes were positioned for soft tissue protection, together with continuous irrigation and suction. B) Nail breaking after milling is demonstrated

2 3.5 mm cortical screws. A suction drainage was inserted during wound closure after abundant irrigation with saline solution.

The post-operative rehabilitation protocol allowed immediate passive knee and hip mobilization with progressive range of motion while no weight bearing was allowed for the first 60 days. Partial weight bearing was allowed after two months and full weight bearing after three months. At the last clinical and radiographic follow-up at 10 months the patient was able to walk with slight limp without aids. Left knee was stable but slightly stiff, with ROM 0-85° (Figure 6).

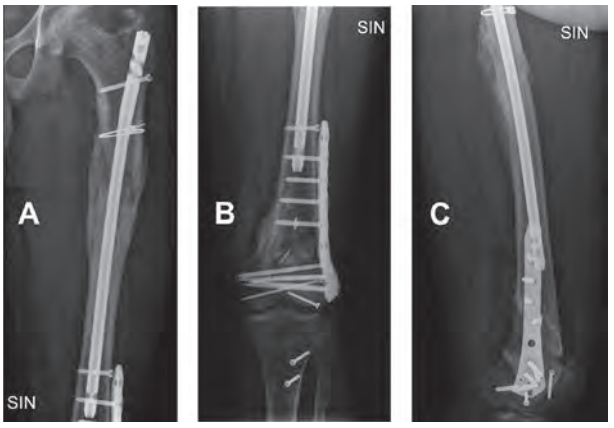

Figure 6. Ten months follow-up radiographs showing complete healing of both diaphyseal and distal femur fractures. A, B) AP view. C) Lateral view

Discussion

The removal of a bent femoral nail represents a challenge for the trauma surgeon. Different authors have reported different techniques for the removal of a bent nail but there is no widely accepted algorithm

for their treatment (10, 16-18). The choice of the technique depends on the degree of deformity, on the direction of the deformity, the location of the deformity, on patient conditions and on the surgeon experience.

An adequate preoperative imaging is mandatory for precise individuation of magnitude and direction of the deformity and to plan both nail removal and definitive fracture treatment. Moreover, the vast majority of femoral bent nails present to the clinician after a high energy new trauma, differently from broken nails which usually occur in case of nonunion and often without trauma (13). Consequently, more soft tissue damage and associated lesions together with worse general conditions may be expected. In case of associated lesions, a damage control approach may be advantageous as it allows to stabilize the patient and to accurately plan definitive surgery. The technique described in the present paper resulted to be safe and effective, comparably to other techniques already reported. Moreover, it allowed to sequentially treat associated lesions without complications.

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Case report

Can UKA after KineSpring system failure be a viable option? A case report

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Summary. *Background and aim of the Work*: The KineSpring System is an alternative treatment offered in selected symptomatic patients suffering from mild to moderate medial knee osteoarthritis (OA). This device reduces medial compartment loads in the OA knee without compromising the integrity of the lateral or patellofemoral knee compartments, maintaining the normal knee anatomy. Currently, papers about KineSpring System installation show promising results. The current authors describe a case of unicompartmental knee arthroplasty (UKA) employed to treat medial knee OA after Kinespring system failure. *Methods*: A 64-year old male patient presented to our hospital after failure of a Kinespring system implantation into his left knee at an external hospital, where the outcomes obtained were not satisfactory. The surgical options discussed with the patient were the TKA or medial UKA. A medial UKA was preferred by the patient. *Results*: One year from UKA, the patient complained of frequent joint effusions and weight bearing pain despite a good ROM without radiographic signs of implant loosening. Therefore, after two years we replaced UKA with total knee arthroplasty (TKA). *Conclusions*: Further experience is needed to provide reliable clinical data about the results of the UKA after KineSpring System discharge. (www.actabiomedica.it)

Key words: KineSpring System, failure, complications, revision surgery, unicompartmental knee arthroplasty

Background and aim of the Work

Medial Knee osteoarthritis (OA) is increased in middle-aged patients (1). When conservative treatment is not able to improve symptoms for long-term, surgical treatments are necessary to relieve pain and gain function (2). Total knee arthroplasty (TKA) should be used as a last option for the most severe cases of knee OA (3). High tibial osteotomy (HTO) is indicated in moderate to severe varus deformity associated with medial compartment overload/osteoarthritis (OA); while unicompartmental knee arthroplasty (UKA) is the viable option to treat medial knee OA with more neutral leg alignment (4, 5). A treatment gap between ineffective conservative treatment and invasive surgical options exists for early-onset medial knee OA (6). Patients are often young and show radiographic mild to moderate OA with pain that limits their daily activities, above all participation in recreational sports (6). The development of new surgical options for younger patients is encouraged (7). The KineSpring knee implant System is an extra-articular and extra-capsular load absorber (8). This device has been proposed as an alternative treatment in selected symptomatic patients with mild to moderate medial knee OA (6, 9, 10). The purpose of this device is to stop the progression of the degenerative process, to relieve pain and to offer a minimally invasive joint sparing and reversible procedure (10). Initial research showed that the Kinespring system is able to provide a significant improvement in knee pain and function, a low complication rate and complete preservation of normal anatomy (9-11). The causes of KineSpring System failure reported in literature are infection, device breakage, intra- and extra-

articular metallosis and persistent pain, stiffness and flexion contracture (10, 12-15). These problems necessitate revision surgery. Our purpose is to describe the clinical course of a 64-year-old patient that underwent to UKA implant after Kinespring system explantation due to continuous pain and stiffness.

Methods

In May 2014, a 64-year-old man underwent a kinespring system implantation in a different orthopedic institution for symptomatic medial overload of the left knee (Fig. 1). This surgical treatment was not successful: the left knee was painful at weight bearing and at rest and stiff with ROM of 10° to 80° for extension and flexion. For these reasons the device was removed in June 2015 by the same surgeon. The surgical excision of the femoral and tibial scars revealed extra-articular metallosis and severe fibro-calcific scar reaction around the implant. The patient then underwent intra-articular hyaluronic acid injections without meaningful benefit, the knee remained very symptomatic with slight lameness upon walking. In December 2015 the patient was assessed at our institution. Clinical examination revealed bilateral varus malalignment of the lower limb and flexion contracture <15 degrees. The left knee showed signs of profuse joint effusion and medial knee compartment tenderness. There was no varus/valgus and anterior/posterior instability on clinical examination. There were no clinical signs of infection or neurological deficits. The range of motion (ROM) of the left knee was 10° to 120° for extension and flexion, respectively. Standard knee X-rays, axial patellar projections, and weight-bearing full-length lower limb radiographs showed medial knee OA (Fig. 2). Magnetic resonance imaging (MRI) of the knee showed advanced degenerative changes in the medial compartment, with all other knee compartments in good shape (Fig. 3). Blood analysis and inflammatory markers (leukocytes counts, ESR, CRP) were normal. Treatment with prosthetic replacement was indicated. The surgical options discussed with the patient were the TKA or medial UKA (16). A medial UKA was preferred by the patient and an elective UKA was planned. On admission in May 2016, his body mass index (BMI) was 26.86 kg/m^2 (1.76 m; 83 kg) and preoperative assessment included the following scores:

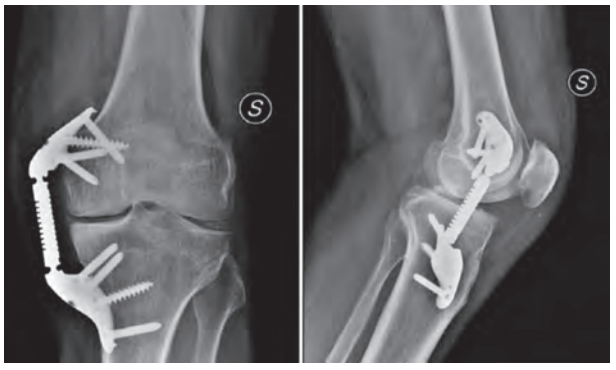

Figure 1. Radiographs of the left knee showing Kinespring system installation

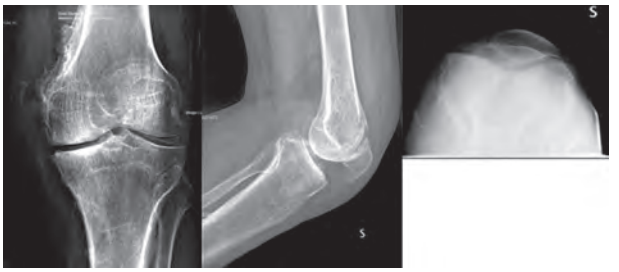

Figure 2. Preoperative radiographs of the left knee showing medial knee OA after Kinespring system explant

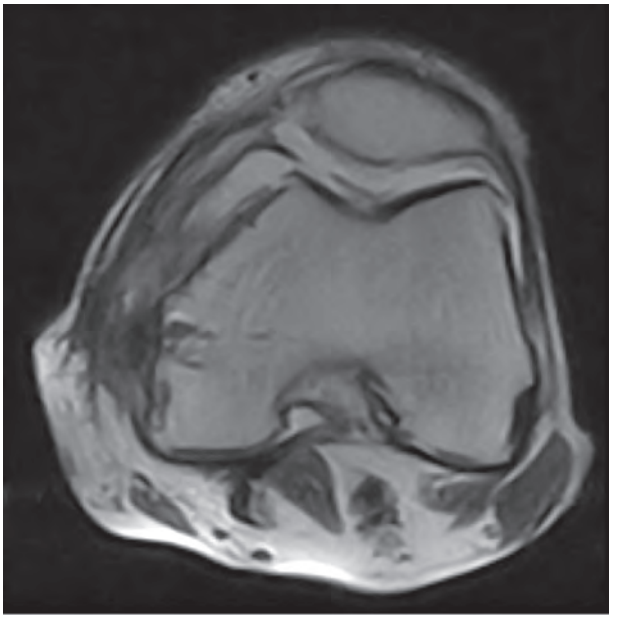

Figure 3. Preoperative MRI of the left knee showing patellofemoraljoint of left knee in good shape

KSS 40, WOMAC score 67.4, IKDC score 28.7 and VAS pain score 9.

Surgical exploration revealed anteromedial knee OA (Fig. 4) and a free lateral compartment. A chondral lesion of the 4th degree according to the Outerbridge classification, about 1 cm in diameter, was detected on the femoral trochlea, with osteophyte below the patella. Anterior cruciate ligament (ACL) was undamaged. Therefore, in agreement with the patient, surgeons implanted a medial UKA (ZUK-Lima) in the left knee (Fig. 5). Postoperative clinical course over two weeks was complications free, with a ROM of 0-90° and mild joint effusion. Weight bearing with Canadian crutches and physiokinesitherapy (PKT) program was allowed on the first postoperative day. One month and three months after surgery clinical examination showed mild knee joint effusion and ROM of 10° to 110°. The knee extension deficit was partially reducible. There was no joint instability. We recommended continuation of the PKT program for recovering ROM and muscle tone, stressing on knee extension recovery.

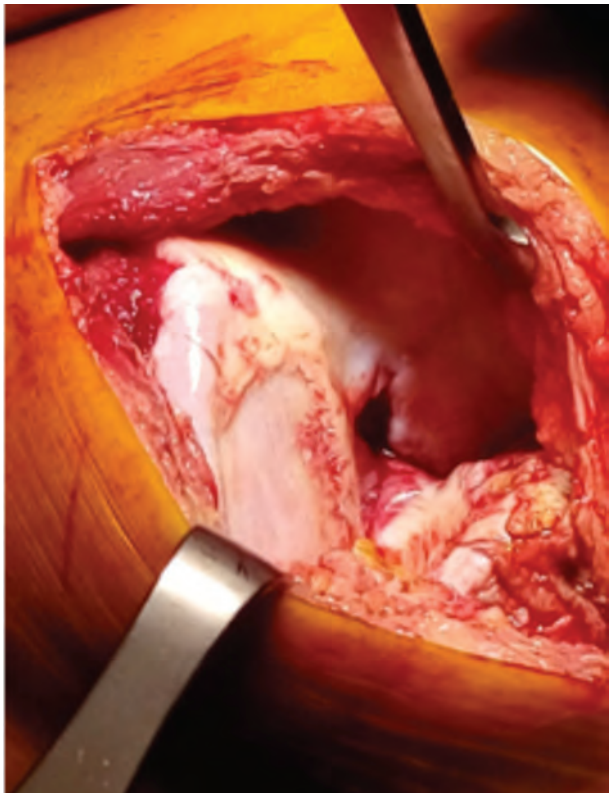

Figure 4. Intraoperative image revealing knee anteromedial OA

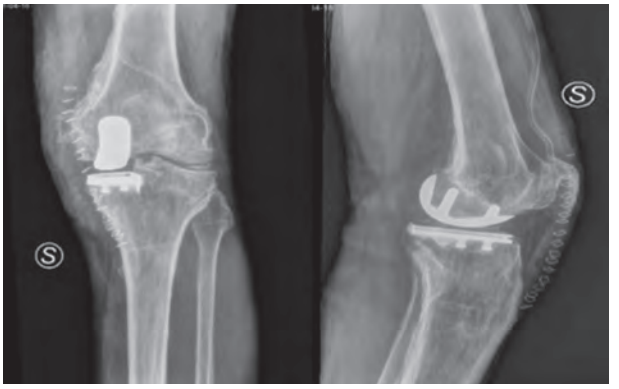

Figure 5. Postoperative radiographs of the left knee following UKA implantation

Results

Six months after surgery, the patient reported improvement in pain and ROM. Clinical examination showed no knee joint effusion, a persistent partially reducible knee extension deficit of about 10°, (like the controlateral knee), knee flexion of 120°, and no joint instability. The functional scores showed a moderate improvement: KSS 66, WOMAC score 73.5, IKDC score 67.8 and VAS pain score 3 with mild pain during up- and down-stairs ambulation.

One year after replacement, patient reported some pain during daily activity and recurrent joint effusions. Range of movement (ROM) of left knee was 10° to 100°, functional scores were the same as previously. Knee X-rays were performed at each clinical follow-up. There were no signs of prosthetic loosening or osteolysis. We recommended continuation of the PKT program to improve symptoms and function.

The patient returned for a 2-year follow-up after surgery (Fig. 6) showing the same problems and a mildly swollen left knee. There were no clinical signs of knee infection. Therefore, the revision of UKA to TKA was recommended in agreement with the patient and an elective TKA was implanted (Fig. 7).

Conclusions

More than 4 million Americans suffer from knee OA compromising walking ability (6, 17). Only 500,000 knee arthroplasties and HTOs are performed

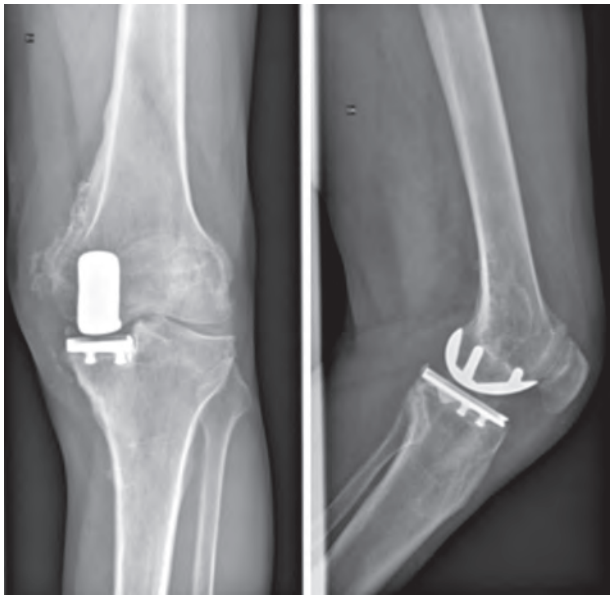

Figure 6. Radiographs of the left knee following UKA implantation after 2 year of replacement

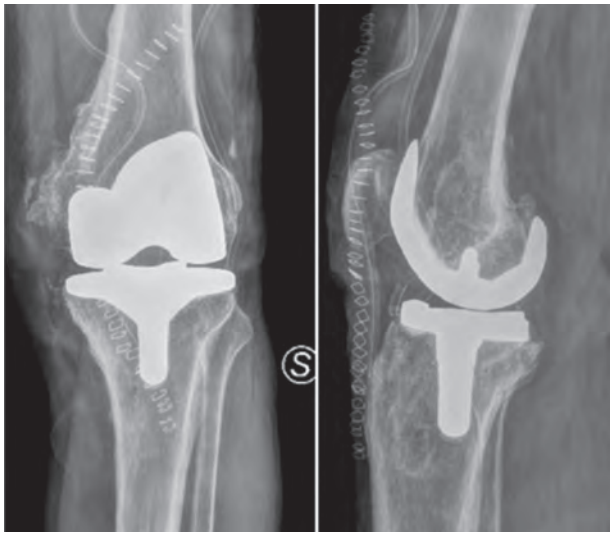

Figure 7. Postoperative RX of the left knee following TKA replacement

annually in America, representing only 13% of all patients with debilitating symptoms (18). These estimates are due to the fact that many patients are in the treatment gap between ineffective conservative treatment and invasive surgical options for many years (6).

The Kinespring implant has been proposed as an effective alternative to HTO and UKA when mild to moderate but symptomatic medial OA affects the knee (6, 9, 10). The Kinespring system would fill the treatment gap for those OA patients who are no longer relieved by palliative and/or conservative treatment and who are not willing to consider arthroplasty or osteotomy, or for whom arthroplasty or osteotomy are not indicated (8).

However, patients must be correctly selected according to the inclusion and exclusion criteria showed in literature (9, 10, 15). This device seems to be a true tissue sparing procedure that does not alter the knee biomechanics, and is readily accepted by patients due to the reversible nature of the procedure (9, 10). The Kinespring system reduces medial compartment loads in the OA knee without compromising the integrity of the lateral or patellofemoral compartments (19). This system can modify the progression of knee OA by increasing the joint space and improving subchondral bone trabecular integrity (20). Theoretically, anatomical structure remain intact with this implant and the device may be explanted, if needed, via the same access route without compromising future surgical options (19).

Reports that have examined the effectiveness of the Kinespring system carried out a follow-up after 12 months, 2 years and 5 years. Currently, papers about Kinespring system installation show promising results (6, 10, 15, 20).

Previous research has suggested that with a five-year lifespan of the implant, the Kinespring system demonstrates significant economic advantage over other surgeries and conservative methods (21). However, this device is not complication-free. Infection, device breakage, intra- and extra-articular metallosis, mechanical failure, soft tissue intolerance and very difficult to diagnose and to treat knee pain are listed (10, 12-15) among the complications.

These complications, thus, represent a problem necessitating revision surgery and device explant. Further research regarding the biomechanics and risks of the Kinespring system implantation and explantation are needed. Indeed, local intra- and extra-articular metallosis, soft tissue damage especially to the medial joint capsule and the medial collateral ligament, synovitis and joint effusion due to intrarticular metallosis and medial joint instability after device explant can make subsequent surgical treatment difficult (14).

Bowditch et al. (12) reported device infection after 6 weeks following surgery. The load absorber system was removed and antibiotic treatment was performed. New Kinespring system was implanted 3 months later, after the infection resolved.

Citak et al. (13) removed Kinespring 7 months after its installation due to device breakage and they recommended TKA for extensive metallosis and OA spread to other knee compartments.

Also Schüttler et al. (14) recommended TKA after Kinespring explants. They found extensive synovitis and metallosis, elevated chromium ion levels, full thickness cartilage erosion on the medial femoral condyle and the tibia, joint capsule disruption and medial instability.

Hayes et al., (15) in their case series of 12 patients, reported one patient with knee stiffness at 1,5 years after surgery then resolved, and one patient with deep infection resolved after antibiotic therapy.

Recently, Madonna et al. (10) showed their preliminary results after Kinespring implant in 53 patients after 12 months of follow-up. In 5 of 53 patients revision surgery was necessary. Kinespring system was removed in one patient due to infection after 2 months from surgery and in two patients the implant was explanted after 8 and 10 weeks from surgery due to pain and stiffness that were not resolved.

Our report is the first case of medial UKA implantation after Kinespring system failure. Although after 6 months we have not seen full recovery of range of motion, the patient was satisfied and reported improvement in knee pain and function. However, after two years we replaced UKA to TKA due to continuous painful UKA appeared one year after surgery.

The choice of UKA implantation allows more bone preservation, quicker recovery, decreased blood loss, lower serious complication rate, lower cost, as well as improved range of motion, joint kinematics, and proprioception compared to TKA (22). Preoperative diagnosis, history of prior knee surgery, choice of implant, and patient gender did not seem related with KSS score or the need for revision surgery (23). Performing TKA after HTO is more challenging due to loss of tibial bone stock, soft-tissue scarring, altered slope of the posterior tibial plateau and a shortened patellar tendon. Knee malalignment is more frequent in TKA after HTO than primary TKA and this could be a possible factor accounting for the lower outcomes reported after this procedure (24). Valenzuela GA et al. (24) proved that prior HTO does not affect clinical outcome of a UKA. The results of patients who underwent UKA after HTO are comparable to those of TKA after HTO or primary UKA. UKA revision due to persistent pain and arthrofibrosis was performed in 1.8% and 2.5% (25) of patients, respectively, and outcomes of revision UKA to TKA were similar to primary TKA (26). When the Kinespring knee implant fails, it is important to know that the medial UKA is probably not a viable option, even when the indications for UKA are still present (5). We consider Kinespring implantation non a tissue sparing surgery due to soft-tissue scarring, joint capsule disruption, medial instability and its replacement requires a revision TKA often constrained. In conclusion HTO and UKA are still the most viable solutions to treat medial OA considering the potential advantages of delaying the eventual TKA and the fact that most patients with HTO and UKA rarely undergo revision surgery (27). Further experience is needed to provide reliable clinical data about the results of the UKA after KineSpring System discharge.

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Case report

Rupture of the femoral component and severe metallosis of the knee 10 years after unicompartmental knee arthroplasty (UKA): a case report

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Summary. A case of a 71-year-old man with femoral and tibial osteolysis and severe metallosis of the knee, resulting from abrasive wears of the metal components of a unicompartmental knee arthroplasty, that leaded to the rupture of the femoral component of the prosthesis is reported. An unicompartmental prosthesis, in a varus knee, was implanted in 2007. In March 2017, the patient felt that his knee was becoming increasingly unstable with pain and increasing disability. At clinical evaluation there was an effusion, 110° of flexion and –10° of extension and a slight instability at the varus/valgus stress tests. BMI was 35. In a CT scan performed in June 2017 no signs of alteration were evident, but an X-Ray performed in January 2018 showed a rupture of the femoral component. A revision surgery was performed in February 2018. At the time of revision surgery, the synovitis and the metallosis were evident. A cemented total knee arthroplasty was performed. Samples of the fluid and surface did not show any bacterial growth. Histological examination confirmed the presence of a massive metallosis. The patient had a satisfactory rehabilitation. According to the literature, metallosis and rupture of the prosthetic components due to polyethylene wear after UKA is a common complication. In our case report the elevated BMI and varus knee accelerated the wear of the polyethylene. The aim of this case report is to enhance how an appropriate diagnosis (clinical and radiographic) and early treatment can lead to a successful result. (www.actabiomedica.it)

Key words: metallosis, unicompartmental knee arthroplasty, prosthetic rupture, metal debris, polyethylene wear

Introduction

Metallosis, a serious complication in knee arthroplasty, is a term used to describe the infiltration of metallic wear debris into the periprosthetic structures, including soft tissues and bone (1-3).

We report a case of massive wear of the polyethylene (PE) insert of a unicompartmental knee arthroplasty (UKA) which produced metal-on-metal abrasion between the femoral component and the metal tibial component, leading to the generation of metallic debris in the periprosthetic soft tissue and bone and to the rupture of the femoral component of the implant.

Case report

A 71-year-old man with osteoarthritis of the medial compartment of the left knee (varus knee) received a primary cemented UKA without complications in 2007. His postoperative course was uneventful until March 2017, when he felt that his knee was becoming increasingly unstable, making frequent clicking noises with pain and increasing disability. Since his symptoms were getting worse, the patient came for a clinical assessment in February 2018. At that time, he had severe pain, swelling and an irritating feeling of 'metal on metal' when the knee was moved. At the clinical

evaluation, there was an effusion, but there weren't any other signs of infection (there wasn't any redness and the temperature was similar to the other knee), the range of motion (ROM) was limited (110° of flexion and – 10° of extension) by the swelling and the pain and there was a slight instability at the varus/valgus stress tests. Regarding the general examination, there wasn't anything to report besides a BMI of 35. The patient never had any fever. Blood tests were performed: complete blood count and differential leucocyte count, VES and PCR; the results of these were normal.

Since there were no local or systemic signs of infection, an aspiration was not performed.

In a CT scan performed in June 2017 (Fig. 1) no signs of alteration were evident, but an X-Ray performed in January 2018 (Fig. 2) showed a rupture in the UKA femoral component.

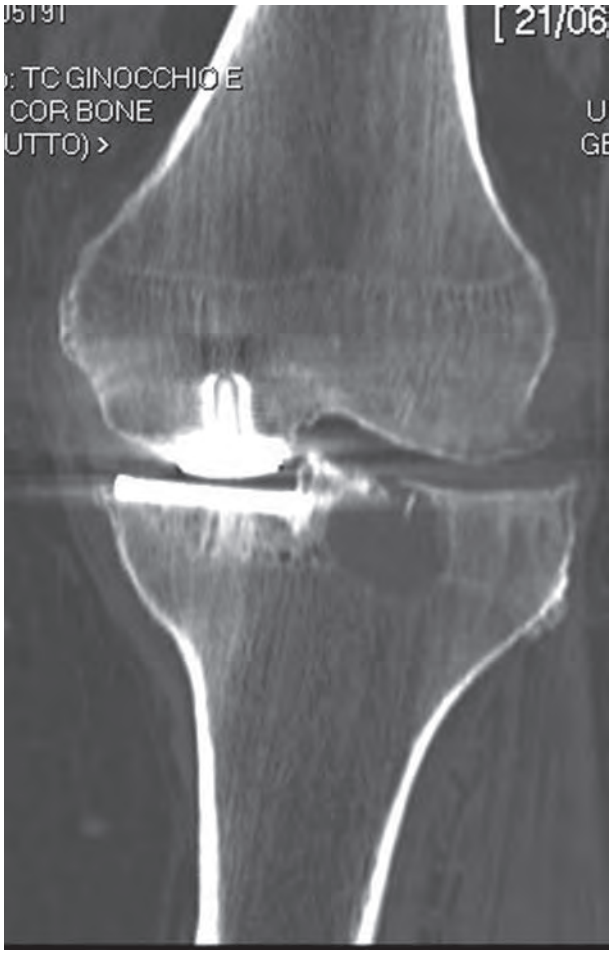

Figure 1. CT scan of the UKA

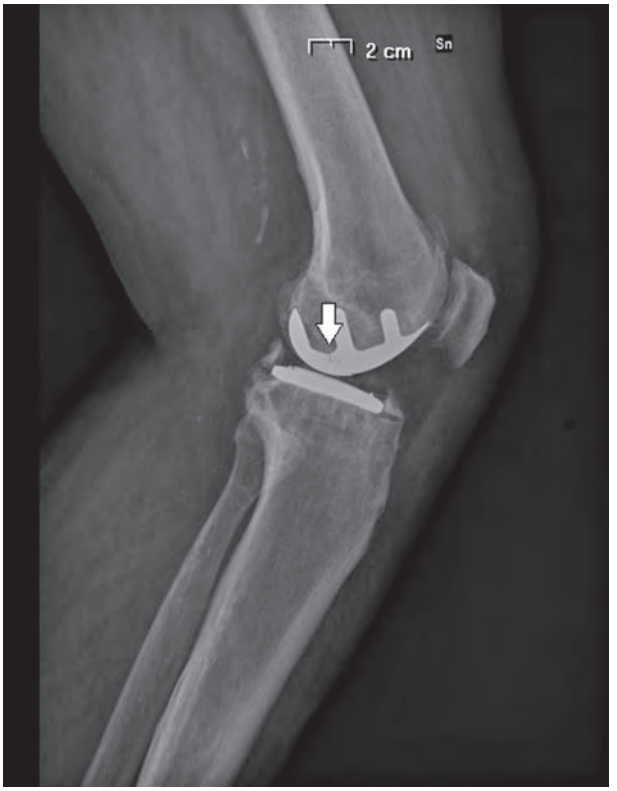

Figure 2. XR in LL projection. The white arrow indicates the rupture of the femoral component

Revision surgery was performed at the end of February 2018. At the time of revision surgery, we noticed a very clear synovitis associated with a massive metallosis. The tibial component was well fixed while the femoral component was broken (Fig. 3-4).

There was a severe wear of the polyethylene tibial insert (Fig. 5) that caused a minor friction between the femoral component and tibial metal surface with a huge abrasion of the metal femoral component. The periprosthetic tissue affected by the metallic debris was cleaned up and several swab samples were taken from the articular structures. Then a cemented medial pivot total knee arthroplasty was performed (revision Advance, MicroPort®) (Fig. 6).

Bacteriological samples of the fluid and surfaces, taken during the surgery from the joint, did not show any growth. Histological examination confirmed the presence of a massive metallosis with a large amount of opaque pigment in histiocytic cells.

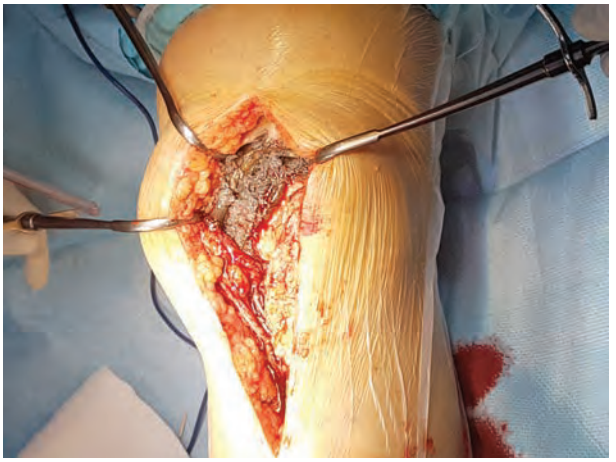

Figure 3. At the exposure of the articular cavity the metallosis and the synovitis were clear

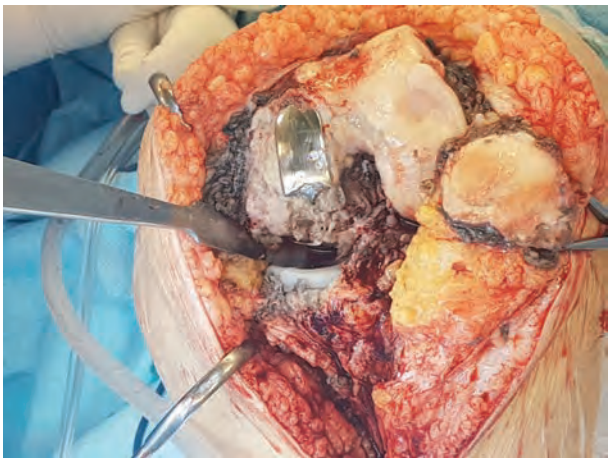

Figure 4. Intraoperative view of the broken femoral component and the wear of the polyethylene insert

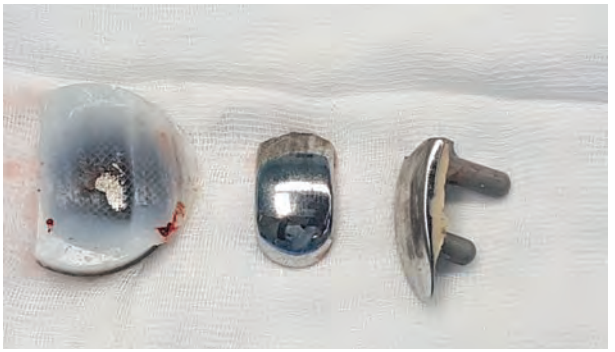

Figure 5. Tibial and broken femoral component of the prosthesis

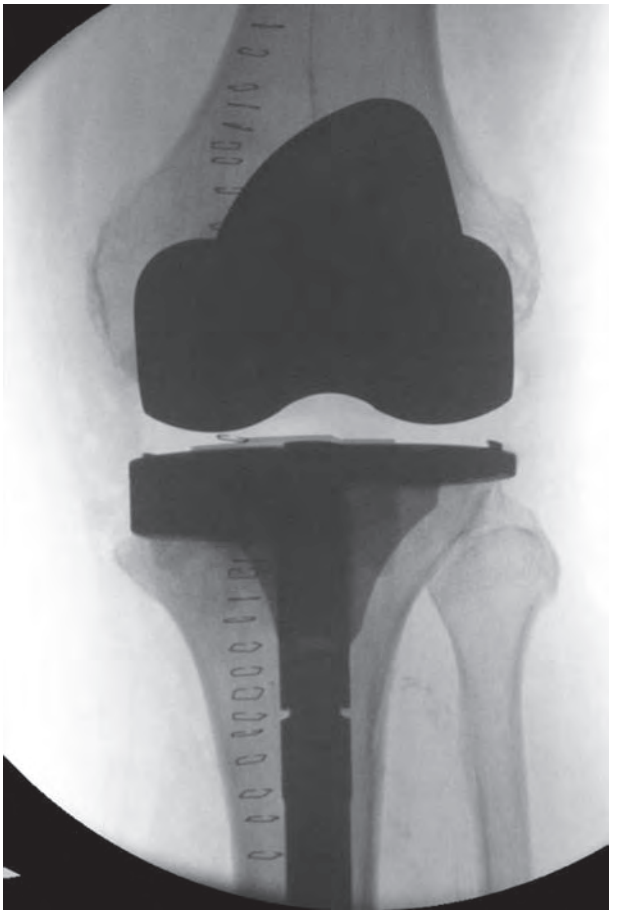

Figure 6. Fluoroscopic image of the revision total knee arthroplasty

The patient had a satisfactory rehabilitation from the revision surgery. After two months, the range of motion was optimal (flexion 130° and extension 0°), the knee was stable and the patient was able to walk without any support.

Discussion

Common complications reported after performing UKA include: unclear pain, rupture of the medial or lateral collateral ligaments, dislocation of the polyethylene bearing, dissociation of the prosthesis components, degenerative changes in the opposite component and fracture of the medial proximal tibia (4-6).

Previous literature reported that failure of UKAs can be caused by: aseptic loosening of the femoral or

tibial component, dislocation or instability of the prosthesis, malalignment of the prosthesis, deep infection, periprosthetic fracture, abrasion of the polyethylene liner and the progression of arthritis (7, 8). Among these, the main causes of UKA failure are: aseptic loosening, infection, patellofemoral pain, deterioration in the opposite compartment and polyethylene tibial insert wear (9-12).

More than half of the failures of UKA are due to polyethylene wear. Potential factors that can play a role in this complication include: time in situ, high localized contact stresses resulting from lack of congruency due to the geometry of the articulating surfaces, increased freedom of rotation, conservative resection of the bone, elevated BMI of the patient (13).

A metallosis permeating the periprosthetic soft tissue can be easily identified; in our case the metallosis was so severe that it could be seen radiographically and this situation should have alerted the orthopaedic surgeon to the urgent need of a revision surgery. Early revision seemed to be the best solution to prevent progressive joint destruction. Moreover, some authors recommend, in case of metallosis, a complete removal of metal wear particles in order to avoid possible immunological reactions, as well as periprosthetic osteolysis following the release of bone resorbing cytokines (14).

From a pathophysiological point of view, three mechanisms can be involved in the development of a chronic inflammatory arthritis by metal debris following a joint replacement. These mechanisms include metal hypersensitivity, direct toxic effect of the ionic metal particles and particle induced synovitis.

The presence of microscopic debris particles in the soft tissues induces a foreign body inflammatory reaction with a histiocytic infiltrate and multinucleated giant cells. Inflammatory cells infiltrate the synovium and causes synovial hyperplasia, giving the histopathologic evidence of black material in the synovium. This is usually associated with an acutely painful effusion.

The attempt to encapsulate the immunogen agents results in a fibrotic response due to the inflammatory cytokines, such as interleukin-1, released by histocytes that engulf the metallic particles (15). These cytokines may cause the periprosthetic osteolysis associated with implant loosening.

Conclusions and clinical message

According to the literature, metallosis and rupture of the prosthetic components due to polyethylene wear after UKA can be an uncommon severe complication leading to a significant functional impairment. Orthopaedic surgeons should be aware of the pertinent clinical and radiographic signs and be prepared to perform an extensive revision surgery to restore joint function. As seen in this case of severe chronic metallosis, where our patient demonstrated risk factors for the accelerated wear of the PE (elevated BMI and varus knee), an appropriate diagnosis (clinical and radiographic) and an early treatment can lead to a successful result.

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Case report

Atraumatic acute bilateral quadriceps tendon rupture in a patient with bilateral patella spurs. A case report and review of literature

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Summary. *Background and aim of the work:* The spontaneous and simultaneous rupture of both quadriceps tendons is uncommon and has rarely been reported in medical literature. The current case involves a 62-years old man with bilateral atraumatic complete quadriceps tendon rupture. Aim of this study is to provide a systematic review of this case and a literature review of similar cases. *Methods:* We reviewed and analyzed this patient's records. Initial x rays of both knees showed a bilateral patellar spur. Real time ultrasonography scan of both knees showed a complete tear of quadriceps. The repair has consisted on end to end Krackow sutures associated with bone suture to the proximal pole of the patella using patellar drill holes. We also researched the literature for bilateral simultaneous rupture of the quadriceps tendon. *Results:* The patient suffered only from seasonal asthma (receiving only inhaled corticosteroids) and he was overweight (BMI: 33,5), he did not do any type of sport, he was a biker. The patient was able to walk after 3 weeks with both knee cast. The patients had a 120° pain free range of motion in both knees 4 months after surgery. *Conclusion:* Simultaneous bilateral quadriceps tendon rupture is really very rare and these are generally reported as case presentation in the literature. This injury usually presents in middle aged people with a history of chronic illness. The general recommendation is to perform surgical intervention within 48-72 hours after injury. (www.actabiomedica.it)

Key words: quadriceps, tendon, bilateral, rupture, patellar spur, ultrasonography

Introduction

Atraumatic acute bilateral rupture of both quadriceps tendons has been rarely reported in the literature and is usually observed in patients aged over 40 years (1); a male:female ratio of 6:1 has been recorded for this phenomenon (2). This extremely rare condition has been published in the literature with systemic diseases such as chronic renal failure (3), diabetes mellitus, rheumatoid arthritis, chronic tendinopathy, amyloidosis and long-term use of systemic or local corticosteroid injections (4). Degenerative changes associated with ageing and calcific tendinopathy has also been shown to be a factor with quadriceps tendon rupture. The most commonly reported mechanism is the sudden reflexive eccentric contraction of quadriceps, with the foot anchored to the ground and the knee flexed (5). Diagnosis is easily suggested by inability to actively extend the knee but it is still often overlooked in the emergency (6). The general recommendation is to perform surgical intervention within 48-72 hours after injury because of only prompt surgical repair shown to result in good to excellent range of motion and return to sport in most studies (7). We report a case of a patient who has sustained of an acute bilateral quadriceps' tendon tear. Accordingly, we present patient's records, clinical examination, imaging data and the management employed.

Case report

The authors have obtained the patient's informed consent for print and electronical publication of the case report. On 7th February 2008, at 8.30 p.m. a man aged 62 years was admitted to our hospital with pain and swelling in both knee and inability to walk. He fell down one step at home. Physical examination revealed anterior swelling and a gap in quadriceps tendon 2-3 cm above the patella in both knees. He reported pain level of an 8 on visual analogue scale. The patient was unable to actively extend his knee. The patient exhibited good general condition. He suffered only from seasonal asthma for whom he was receiving inhaled corticosteroids and he was overweight (BMI: 33,5), no other co-morbidities were noted. He did not do any type of sport, he was a biker. Initial x rays of both knees were obtained and showed a lowering of patella with a bilateral patellar spur (a bone prominence at the quadriceps tendon insertion point of the proximal pole (Fig. 1, 2, 3, 4). Acute bilateral quadriceps tendon rupture was evoked. The patient subsequently underwent ultrasonography scan (Fig. 5, 6) which confirmed simultaneous rupture of both quadriceps' tendon 1-2 cm superior to the patella. Laboratory tests were normal. Hemostasis assessment, renal function, sugar level

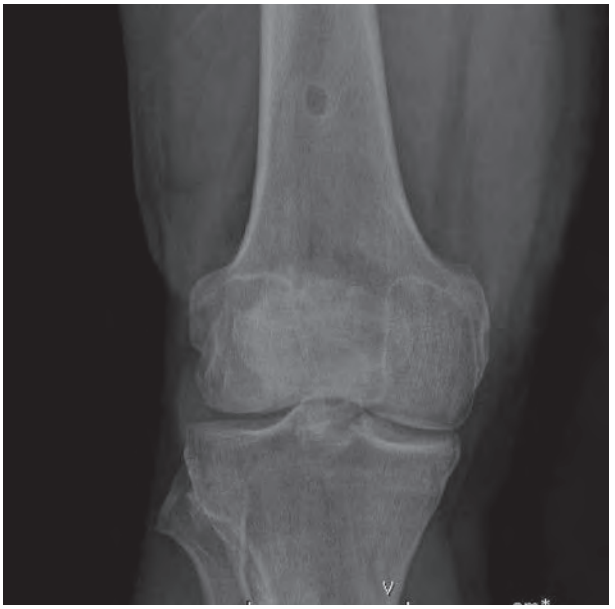

Figure 1. AP e lateral Radiographs of right knee demonstrating a proximal patellar pole spur (with arrow)

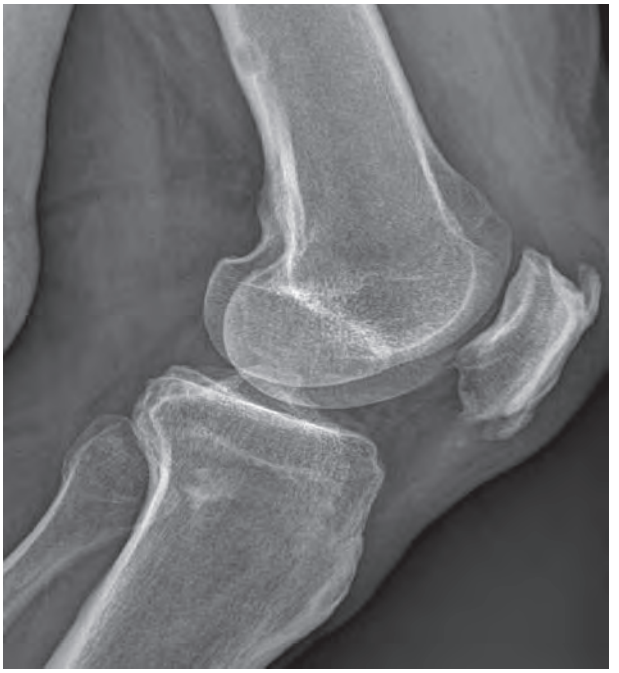

Figure 2. AP e lateral Radiographs of right knee demonstrating a proximal patellar pole spur (with arrow)

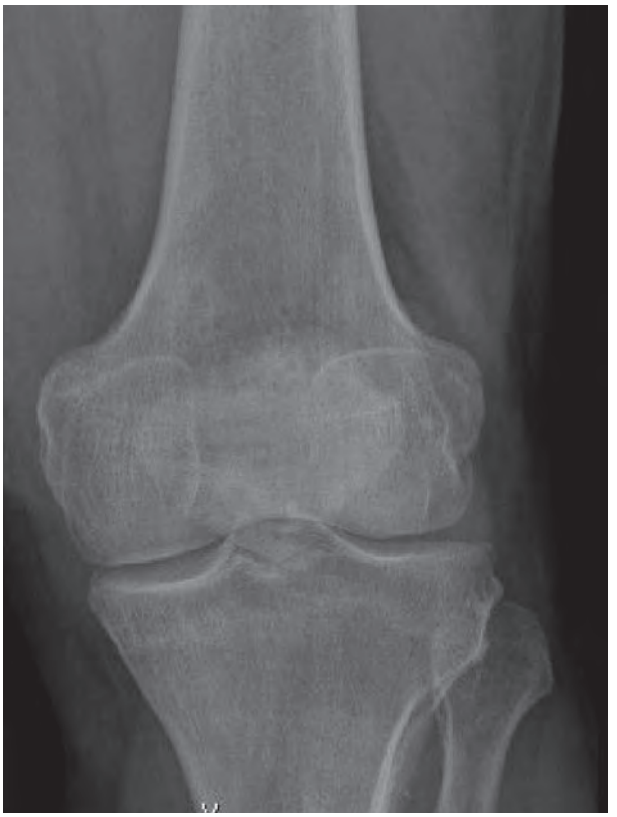

Figure 3. AP e lateral Radiographs of left knee demonstrating a proximal patellar pole spur (with arrow)

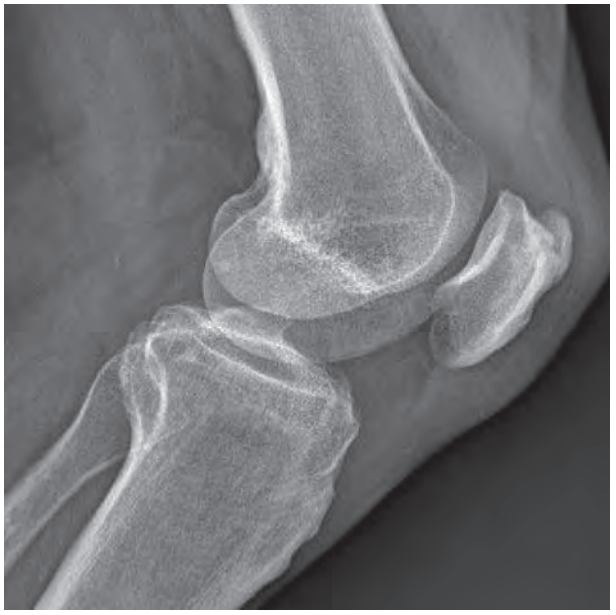

Figure 4. AP e lateral Radiographs of left knee demonstrating a proximal patellar pole spur (with arrow)

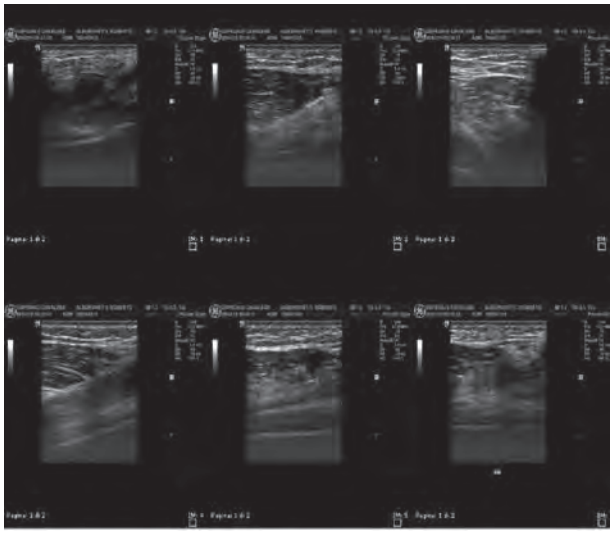

Figure 5. Ultrasonography scan of both knees showing a complete tear of both quadriceps' tendons

was all normal. Heparin was given in the emergency room and the patient was admitted to the orthopedics department. The next morning (14 hours from injury) the patient underwent surgery under spinal anesthesia. Preoperative antibiotic prophylaxis was given (2 grams cefazolin i.v). Both knees were prepared with routine cleaning and draping and a tourniquet was applied.

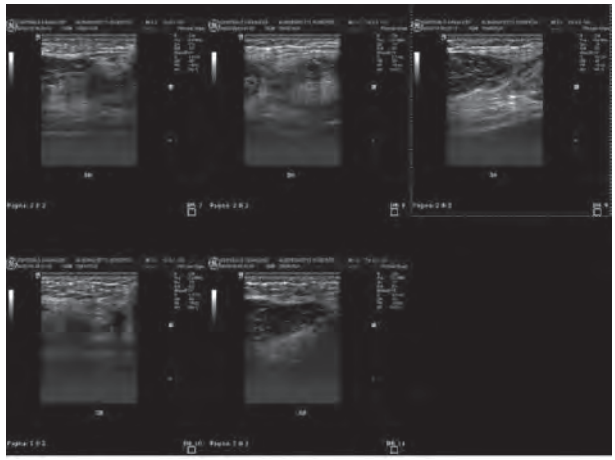

Figure 6. Ultrasonography scan of both knees showing a complete tear of both quadriceps' tendons

Longitudinal skin incision was used for both knees. The quadriceps were visualized, revealing a full thickness rupture of both tendons 1-2 cm proximally the bone-tendon junction (Fig. 7, 8). The distal part of the tendon was reattached using Krakow's sutures associated with bone suture to the proximal pole of the patella using patellar drill holes (we made Krackow point in the tendon stump, which is then passed through the patella using longitudinal bony tunnels). The knees were immobilized in a locking hinged knee brace for 6 weeks. On postoperative day one the patient was allowed to flex at 30 degrees with the brace. The patient

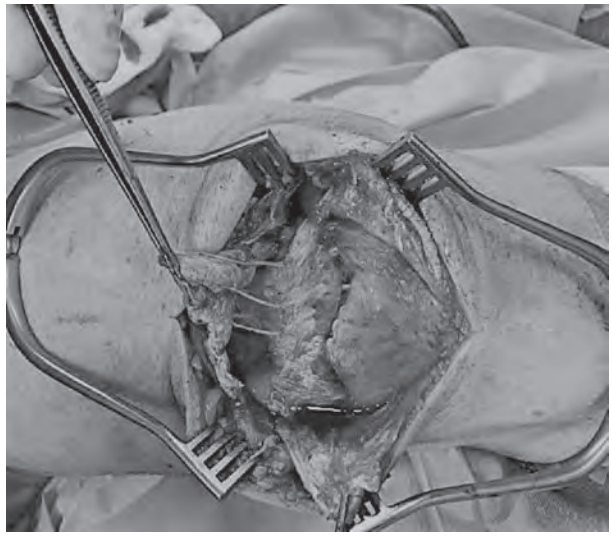

Figure 7. Intraoperative pictures of both knees

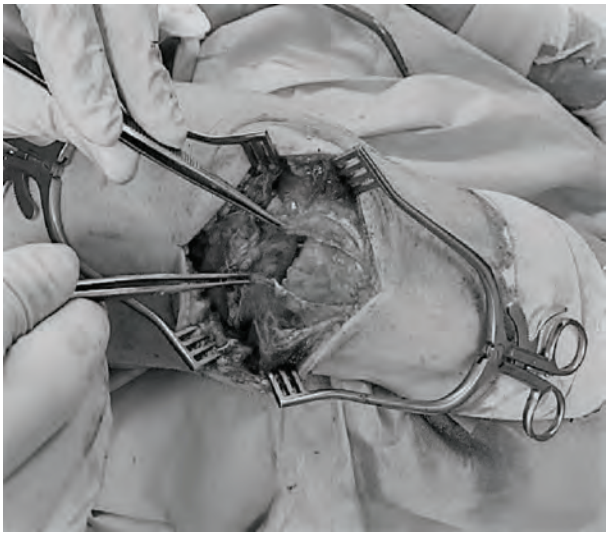

Figure 8. Intraoperative pictures of both knees

was discharged on the second postoperative day. ROM was permitted to increase 10 degrees every 3 days to achieve 90° within 20 days. There were no postoperative complications. The patient was able to walk after 3 weeks with both knee brace in the extended position. The patients had a 120° pain free range of motion in both knees 4 months after surgery (Fig. 9, 10, 11). At 10 months he returned on the bike, the Lysholm Knee Scoring scale was applied to the patient, which showed 88 for the right knee and 94 for the left knee.

Discussion

Simultaneous bilateral quadriceps tendon rupture is really very rare and usually reported as case presentation in the literature (8). The first reported case of simultaneous bilateral rupture of quadriceps tendons had been by Stener and Palmer in 1949 (9). Thes injury usually present in middle aged with a history of chronic illness (chronic renal failure, systemic lupus erythematosus, rheumatoid arthritis, diabetes mellitus, gout, long term corticosteroid use, obesity) that degenerate the intra-tendinous structure of the knee (10). Many cases of bilateral ruptures in athletes consuming anabolic agent have been also reported in literature (11). Moreover, direct corticosteroid injections and fluoroquinolone use have all been associated with increased risk of tendon rupture (11) Though fluoroquinolone use has most commonly affected the Achilles tendon, cases involving quadriceps tendons have also been described (12). In our case there was only history of inhaled corticosteroids and an increased BMI (13). Pain, cracking sensation, active knee extension defect and

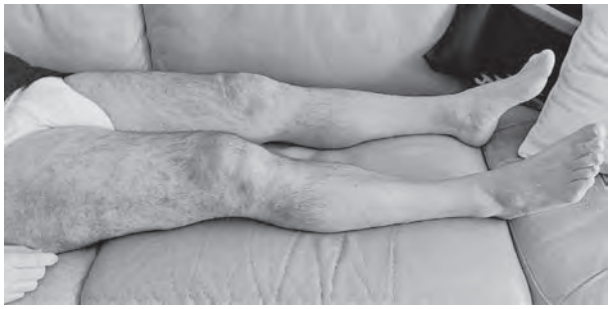

Figure 9. Primary healed scar with full knee extension and full knee flexion at 4 months after operative.

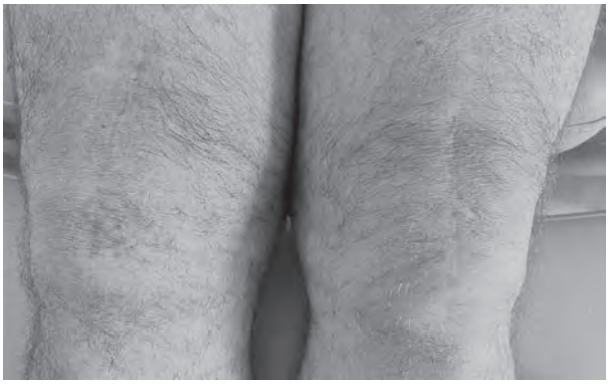

Figure 10. Primary healed scar with full knee extension and full knee flexion at 4 months after operative.

Figure 11. Primary healed scar with full knee extension and full knee flexion at 4 months after operative.

palpable supra-patellar defect are the typical signs and found in about 60% of patients (2). Accordingly, Siwek and Rao (14) in 1981 showed that 28% of ruptures had not been initially diagnosed. Therefore, clinical examination is crucial and allows for rapid diagnosis, which is critical for optimal therapeutic management (5). Anterior posterior and lateral radiograph of knee can objectify supra-patellar soft tissue defect, joint effusion, patella baja or avulsion fragment (15). It has also been suggested that the presence of a patella spur, a bony prominence at the QT tendon insertion point of the proximal pole may be associated with ruptures (16). Ultrasonography has proven to be a better modality than radiographs for the diagnosis if QT ruptures and can further differentiate between partial and complete tears as well as tear location (17). Magnetic resonance has greater sensitivity and specificity than US, however it is more expensive, time consuming and limited by its availability (18). The MRI scan is indicated when there is uncertainty regarding diagnosis and helps differentiate between a partial and complete tear. Although several techniques have been described including end-to-end suture, transosseus patellar tunnels or anchor fixation and also graft augmentation, there is a paucity of literature on the treatment of high- grade quadriceps tendon tears (19). Wenz at al have shown that either technique, compared to simple end-to-end sutures and patellar drilling holes, had no influence on the final outcome (20). Both Anchor suture techniques and transosseus sutures repair techniques do not show any difference in terms of clinical outcomes (21). After surgery walking was permitted protected with a brace keeping the knee extended for 4 to 6 week and not before 3-5 week (in bilateral simultaneous cases), which helps protect the reconstruction a mobilization of 0-30° have reported good functional results, always with complete motion recovery but in mono-lateral cases (22).

Conclusion

Both simultaneous quadriceps tendon rupture is extremely rare but however it must be considered in emergency if the patient has also a little traumatism of both knees associated to active extension deficiency, especially if it is over 40 years old, man, obese and with associated co-morbidities. Imaging should not substitute a good clinical examination. A missed diagnosis may lead to delayed repair, which could be problematic due to significant quadriceps retraction. General recommendation is to perform surgical intervention within 48-72 hours after injury, that allows optimal functional results.

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Case report

Patellar and quadriceps tendons acute repair with suture anchors

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Summary. *Background and aim of the work:* Quadriceps and patellar tendon rupture are relatively uncommon but can result in a disabling condition if untreated. We retrospectively review all our cases treated with suture anchors from 2014 to 2018, to evaluate midterm outcome of this technique. *Methods:* Traumatic and atraumatic quadriceps and patellar tendon preinsertional lesions were acutely treated with Healix Ti and FaStin RC 5mm suture anchors and an aggressive rehabilitation protocol was prescribed to patients. *Results:* Good to excellent results according to the Modified Cincinnati Rating System Questionnaire was obtained at a mean 12 months followup, without major complications. *Conclusions:* Suture anchors are a promising alternative to transosseus suture for acute repair of quadriceps and patellar tendon lesions, but longer followups are needed for detect long-term complications. (www.actabiomedica.it)

Key words: quadriceps tendon, patellar tendon, rupture, suture anchors, acute repair

Background and aim of the work

The extensor mechanism of the knee is made by quadriceps femoris muscle, quadriceps tendon, patellar bone and patellar tendon. Tendon fibers from rectus femoris, vastus lateralis and vastus medialis muscles converge distally, insert on and overtake the base of the patella, while tendon fibers from vastus intermedius insert on the base of the patella and stop there. Moreover, fibers from vastus lateralis and vastus medialis muscle contribute to give raise to lateral and medial retinacula respectively, which help load sharing with quadriceps tendon and have a role in patellar tracking. Patellar tendon is predominantly made by fibers from rectus femoris, originating from the apex of the patella and inserting on anterior tibial tuberosity.

Complete rupture of knee's extensor mechanism is relatively uncommon with quadriceps tendon being more frequently involved (1,37/100000 per year) than patellar tendon (0,68/100000 per year), mainly affecting middle aged men (1).

Despite being a rare pathology, if untreated, this could results in severe disability for the patients (2).

Causes of extensor mechanism rupture can be divided in traumatic and atraumatic; the first group includes sports injuries and penetrating injuries, and the second group includes low energy traumas (eccentric quadriceps contraction during a simple fall) or no trauma at all in patients with predisposing factors like chronic tendinopathy treated or not with steroid injections, previous ACL surgery with use of autologous patellar tendon graft or systemic conditions such as diabetes mellitus, chronic renal failure, secondary hyperparathyroidism, gout, rheumatoid arthritis, systemic lupus erythematosus (SLE), calcium pyrophosphate deposition disease (CPDD), obesity and previous quinolone or steroid use (3).

Clinical presentation is typically represented by acute anterior knee pain, a swollen knee, a palpable gap in the involved tendon and difficulty or impossibility in rise the leg in extended position.

While clinical diagnosis is usually satisfactory,

adding imaging like X-ray, ultrasound and/or MRI is helpful in confirming the clinical diagnosis and avoiding false positive cases (4).

Many techniques are described in literature for acute quadriceps and patellar tendon repair, most of them being represented by tendon-to-tendon suture of mid substance tendon lesions, transosseus sutures for more eccentric lesions with or without cerclage reinforcement (5), synthetic augmentations like mersilene strips (6) or synthetic ligaments (7), tendon plasty (8), and finally suture anchors (9-11).

Materials and Methods

In our department we started routinely repair quadriceps and patellar tendon lesions with suture anchors since 2014, collecting 9 cases in 8 patients. We treated 7 quadriceps tendon lesions (in one case the lesion was bilateral, figure 1 and 2) and 2 patellar tendon lesions. One lesion was caused by a penetrating injury in a quadriceps tendon (figure 3 and 4); all the other lesions were caused by a low energy indirect trauma (eccentric contraction during a fall) in patients with history of systemic conditions like diabetes mellitus, autoimmune diseases and daily use of corticosteroids.

All the lesions were located at the tendon-bone junction.

All patients were men except one woman, and the patients age ranged from 38 to 63 years old at the time of the acute rupture.

We used either FaStin RC 5mm ORtHOCORD with needles or HEALIX TI™ Dual Threaded Suture Anchor for quadriceps tendon and patellar tendon repair.

We made clinical diagnosis with the addition of X-ray in AP and lateral view of the knee and ultrasound confirmation.

Surgical technique consisted of a longitudinal anterior approach to the knee, except in the case of penetrating injury where the transverse wound at the level of the quadriceps insertion was used, an accurate debridement of the hematoma and loose tendon ends was performed, the tendon's footprint was decorticated with a rongeur and multiple drill holes were performed until seeing active bone bleeding. Two anchors for quadriceps tendon repair was used and one for patellar tendon, suturing the tendon stump with a Krackow suture. A horizontal mattress reinforcement stitch on the tendon stumps was made with a 0 absorbable suture, as the repair of medial and lateral retinacula, after tensioning the suture anchor stitches. Confirmation of anchors placement and the hight of the patella was obtained by final fluoroscopy.

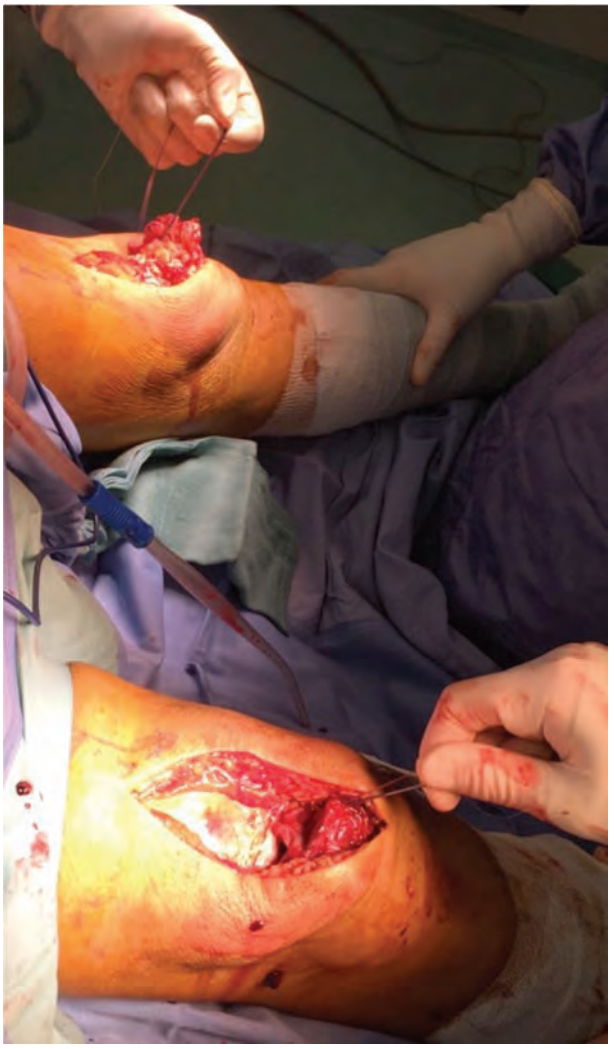

Figure 1. Bilateral quadriceps tendon lesion: suture anchors placement at the base of the patella

All the surgeries was performed under spinal anesthesia and mild sedation based on anesthetist's and patient preferences.

Postoperative rehabilitation protocol consisted of 4 phases: the first postoperative week the knee was

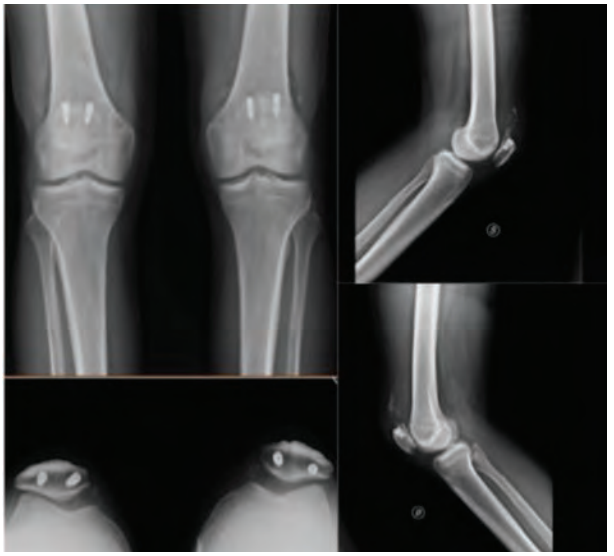

Figure 2. Postoperative X rays of bilateral quadriceps tendon lesion: lateral left and right knee view showing slight heterotopic ossifications

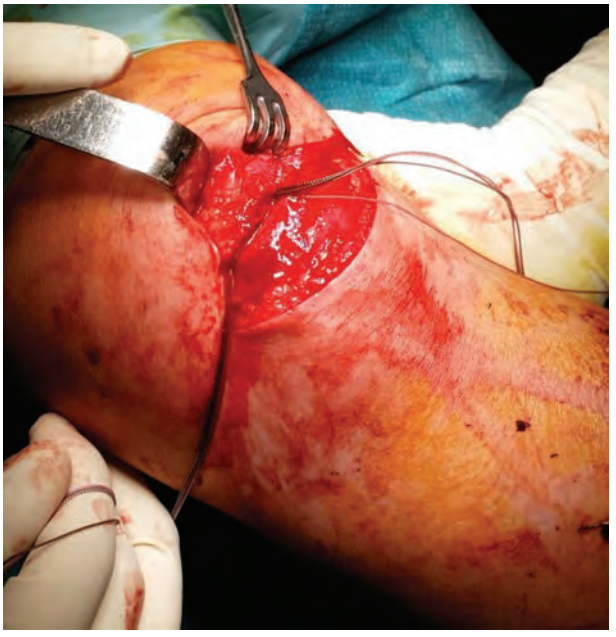

Figure 3. Transverse penetrating injury of the quadriceps tendon: suture anchors' stitches thightening before mattress suture reinforcement

blocked in an articulated brace at 0° to protect the surgical skin wound. At this time quadriceps settings and ankle pump was encouraged and cryotherapy was prescribed 20 minutes every 2 hours as the use of elastic stockings. Walking with crutches was allowed as tolerated. During the weeks 2 to 6 the brace was regulated on a 0°-90° range, prescribing a gradual regaining of ROM with passive exercises, keeping on quadriceps settings and ankle pumps; walking with crutches as tolerated and short arc active extension exercises. During the weeks 6 to 12 was prescribed brace discharge, gradual crutches discontinuation and discharge and active/passive ROM exercises to regain full ROM. After the 12th week, gradual and complete return to activities of daily living (ADL) was encouraged.

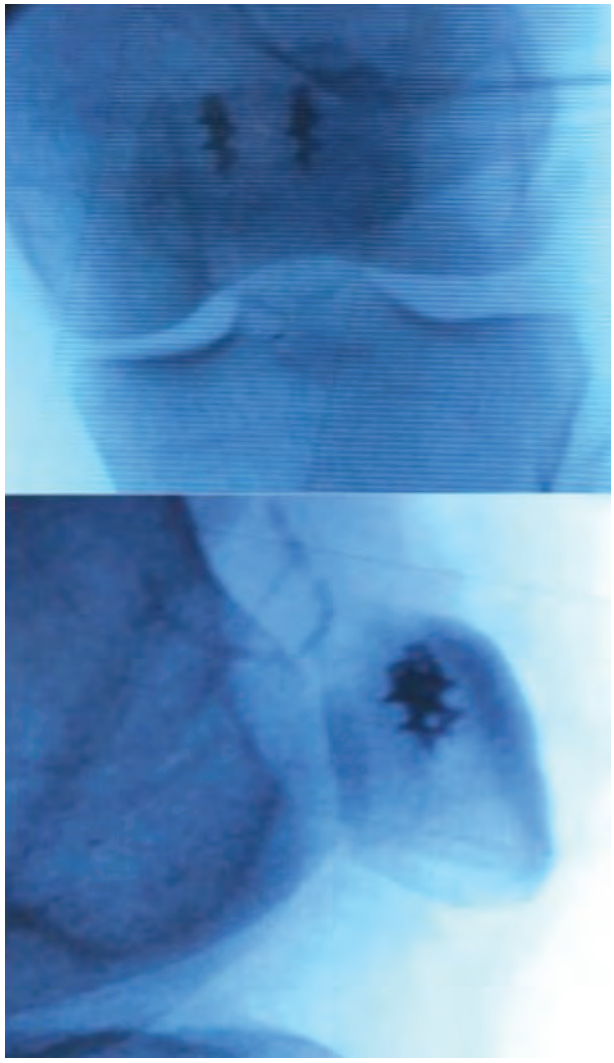

Figure 4. Transverse penetrating injury of the quadriceps tendon: intraoperative AP and LL fluoroscopy assessment of anchors placement

The followup period ranged between 9 and 15 months postoperatively.

Results

We evaluated the Modified Cincinnati Rating System Questionnaire for the injured knees after a minimum of 9 months postoperatively, recording a mean value of 81 points (excellent value >80 points), with the worst value recorded for the bilateral lesion (64 points) and the best one recorded for an athletic young man who returned to sport activities (90 points).

All patients were able to return to ADL, the mean loss of knee flexion related to the uninjured knee was 12° and no major complications like surgical wound complications, infections, deep venous thrombosis and reruptures were detected. Only one patient developed heterotopic ossification of the quadriceps tendons, apparently without clinical relation.

Discussion and Conclusions

Quadriceps and patellar tendon rupture are relatively uncommon pathologies but can result in a disabling condition if left untreated. Even when promptly surgically treated, some complications, related to postoperative immobilization like clinical relevant loss of knee flexion, quadriceps muscle atrophy, decreased patellar mobility, patellar stiffness and persistent pain are common (13).

The most common treatment for acute patellar and quadriceps tendons rupture involves the use of sutures through transosseus patellar bone tunnels. Because of the different types of rupture and the possibility of poor quality tendon tissue, the surgeon should always be prepared to combine different techniques to obtain the best repair possible, achieving a safe and early mobilization of the injured joint, to minimize the sides effects of open surgery like arthrofibrosis.

In our series we present the use of a suture anchor that is our first choice in treating this condition; we had no major surgical complications and all patients returned to a normal life in a mean period of 4 months.

The small sample size and the lack of a control group are main limitations of our study.

Use of suture anchors for primary repair of acute quadriceps and patellar tendon preinsertional lesions is a promising surgical technique that allows good results thanks to a great primary tensile strength (9) and advantages like simplicity, smaller skin incisions probably reducing the risk of surgical wound complications, shorter operative time, allowing an aggressive rehabilitation protocol, potentially avoiding specific complications of transosseus sutures like longitudinal patellar stress fractures (12).

Care must be taken to some points of the surgical technique: a good debridemnt of the tendon stumps and the corresponding tendon footprint until bleeding tissue is reached ensure long therm strength of the tendon scar tissue; avoid penetrating the articular surface of the patella with the anchors, checking under direct and fluoroscopy vision; ensure an adequate distance between the anchors, depending on the bone quality, to avoid intraoperative patellar fractures; and correctly place the suture anchors on the tendon footprint, to avoid changing in the native "Q angle" and potential patellar maltracking problems, though it seems to be more a theoretical than a clinical problem (5).

On the other hand the only disadvantage in relation to transosseus sutures appears to be the implant cost.

Anyway, despite good short and mid-term results, further studies should evaluate potential complications in long term follow-ups.

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Case report

Schwannoma of the foot: report of four cases and literature review

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Summary. Schwannoma is a soft tissue tumor that rarely presents in the foot. Patients are usually asymptomatic, but in some cases symptoms typically result from the mass effect and direct involvement of the nerve and surrounding tissue. We report on four consecutive cases. The first patient was a 57-years-old female that referred symptoms similar to the Morton's neuroma with a mass arising from the medial plantar nerve. The second patient was treated for a schwannoma in the plantar area. The third case was a female with a schwannoma arising from the sural nerve and the fourth patient had a tumor arising from the medial plantar nerve. All patients underwent surgical excision and histological evaluation. No signs of neurological deficit or recurrence were observed at final follow-up. Purpose of the study was to define clinical features, optimal management and outcome of schwannomas of the foot, through an accurate review of the literature. (www.actabiomedica.it)

Key words: soft tissue tumors, Schwannoma, foot, diagnosis, benign tumors, differential diagnosis, extremities, pain

Introduction

Schwannoma, also known as neurilemoma, is a benign encapsulated soft tissue tumor classified under the group of peripheral nerve sheath tumors (PNSTs) (1). Schwannoma is a well-circumscribed lesion, arising from Schwann cells of the peripheral nerve sheath (epineurium) (1). It represents about the 5% of all benign soft-tissue neoplasms, with low rate of local recurrence (less than 1%) (2). The malignant degeneration is extremely rare (3-5) but it is difficult to distinguish schwannomas from a malignant peripheral nerve sheath tumors (6). Traumas, Carney's complex, and neurofibromatosis (NF) type 1 or 2 might play an etiological role in the development of this tumor (1, 7-9).

Schwannomas affect man and woman equally with peak age at diagnosis of 30-40 years, and are usually localized in skin or subcutaneous tissue (10). They are uncommonly found in the foot (11-13). In one single center retrospective review, only 10,3% (14 of 137) of the tumors were located in foot or ankle (13), whereas in the Rizzoli Institute experience, only 14 schwannomas out of 189 benign tumors of the foot have been treated from 1990 to 2007 (11). In another study, only 12 of 104 cases (11,5%) observed during a 32 years' period, were located in the foot or ankle (12). The clinical presentation depends on the site and tumor volume: symptoms will typically result from the mass effect and direct involvement of the nerve and surrounding tissue. Most of the lesions are asymptomatic. The typical solitary tumors present as a slow growing painless mobile mass, which may have been present for at least one or two years (1, 4). The discovery of one schwannoma should be careful search for others. The imaging appearance of schwannoma is a not calcified tumor, clearly detectable with ultrasonography and MRI, while usually not appreciable with normal x-rays. There can be bone remodelling due to pressure

and impingement from the tumor, without signs of bone invasion. Multinodular/plexiform schwannoma is an extremely rare variant (2%-5%) usually affecting skin or subcutaneous tissue of the head, neck and flexor surfaces of extremities (4, 6, 14). Most of these are small (maximal diameter less than 2 cm) originating from superficial nerves.

Aim of our study was to report four representative cases of schwannomas of the foot, describing clinical and imaging findings, type of treatment, oncologic and functional outcomes. Further objective was to critically analyze and compare our results with those reported in literature.

Material and methods

We retrospectively studied and report four consecutive patients with schwannoma of the foot observed in the same institution since 2000 to date: no history of trauma or previous pathological condition of the affected foots were observed.

Case 1

A 57-years-old female complaints right foot pain for 1 year. Symptoms were very similar to the Morton's neuroma with pain and parestesia of the plantar region of the forefoot at the second intermetatarsal space. Radiographs showed no bone abnormalities or any tumor-like calcified masses whereas the MRI revealed an oval-shaped lesion of 1cm x 1.5 cm between 2nd and 3rd metatarsal bone (Figure 1A). A second MRI performed 1 year later (few days before surgery) did not show any significant increase of the tumor volume. Surgery was performed through a mini-invasive plantar approach. The gross appearance of the lesion was a round white-yellow mass of about 1 cm in diameter, encapsulated and well delimited to the other near tissues, strictly adherent to medial plantar nerve (Figure 1B). Histology showed a schwannoma with no evidence of malignant transformation (Figure 2). The patient was able to walk with some limitations and dysesthesia to the plantar aspect of the foot one month after surgery, whereas at two months of follow-up she comes back to her all day living activities.

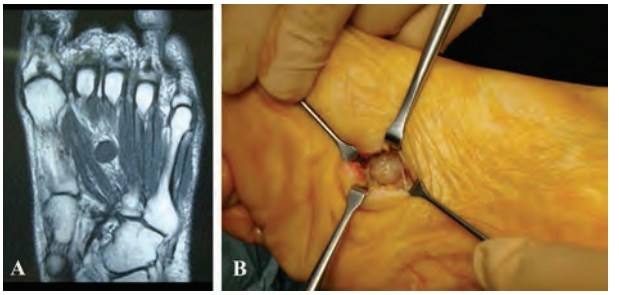

Figure 1. Case 1. A) Axial T2-weighted image demonstrating a fusiform isogenous mass. **B)** Intraoperative finding of the well-circumscribed, encapsulated and solid mass along the medial plantar nerve

Case 2

A 45-years-old male complaints right foot pain and swelling in the plantar aspect of the midfoot that prevent him to attend to his normal activities, including running. Plain radiographs and MRI were performed. MRI images were suggestive of a synovial angiomatosis mass due to proximity to vessels. The patient was operated on and the diagnosis of specimen was synovial angiomatosis. Six months later the patient complained the same symptoms and showed an antalgic supination of the foot. A new MRI revealed tumor-like tissue still present in the plantar region of the foot suspected for local recurrence. Histologic analysis after second operation revealed a schwannoma. Symptoms disappeared immediately after surgery and the patient was able to walk as soon as the surgical wound has healed. There was no sensory deficit on the sole of the foot. The patient come back to his activities of daily living three weeks later.

Case 3

A 58- years-old female complaints left foot pain in the last 4 years. She had stated a slow-growing swelling under the lateral malleolus. At the onset, she experienced pain with palpation of the mass (that was like a peanut), causing some difficulties during walk. MRI with and without contrast showed a mass arising from the sural nerve near the lateral malleolus. The tumor was completely removed, and definitive diagnosis was schwannoma. The recovery was fast without complication.

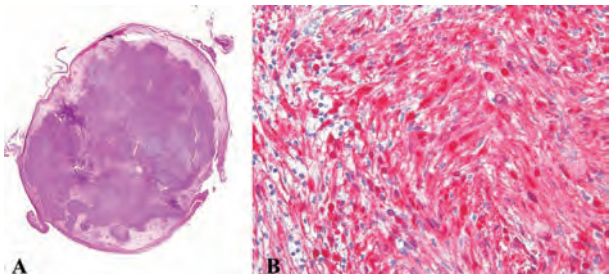

Figure 2. Case 1. Histological feature exhibits A) low power transverse section through the mass showed a neurogenic, spindle cell proliferation with biphasic pattern of growth and prominent nuclear palisading. (hematoxylin and eosin stain, magnification 10×); **B)** The spindled cells arranged haphazardly within the loosely textured matrix. Classic pattern of Antoni B areas (Hematoxylin–eosin original magnification × 400)

Case 4

A 35-years-old female was referred to our institution with a 2-year history of a slowly growing, painful mass in the medial aspect of the right ankle. The patient's past medical history was unremarkable and there was no history of antecedent trauma. On physical examination, a poorly mobile, painful tender mass was noted (Figure 3A). Tinel sign was positive, with radiation of the pain into the plantar aspect of the foot. MRI demonstrated a fusiform lesion with iso-signal intensity on T1-weighted sequences and homogeneous high signal intensity on T2-weighted sequences (Figure 3B,C) along the course of the medial plantar nerve. Based on these features, a schwannoma was strongly suspected and the patient was scheduled for surgery. A surgical enucleation was performed under general anesthesia (Figure 3D,E), and the histological evaluation confirmed the diagnosis of schwannoma, with no signs of malignant features. The postoperative course was uneventful. After two weeks, the sutures were removed and she started progressive weight bearing. Patient referred excellent pain relief and no signs of local recurrence were observed up to final follow-up of 4 years.

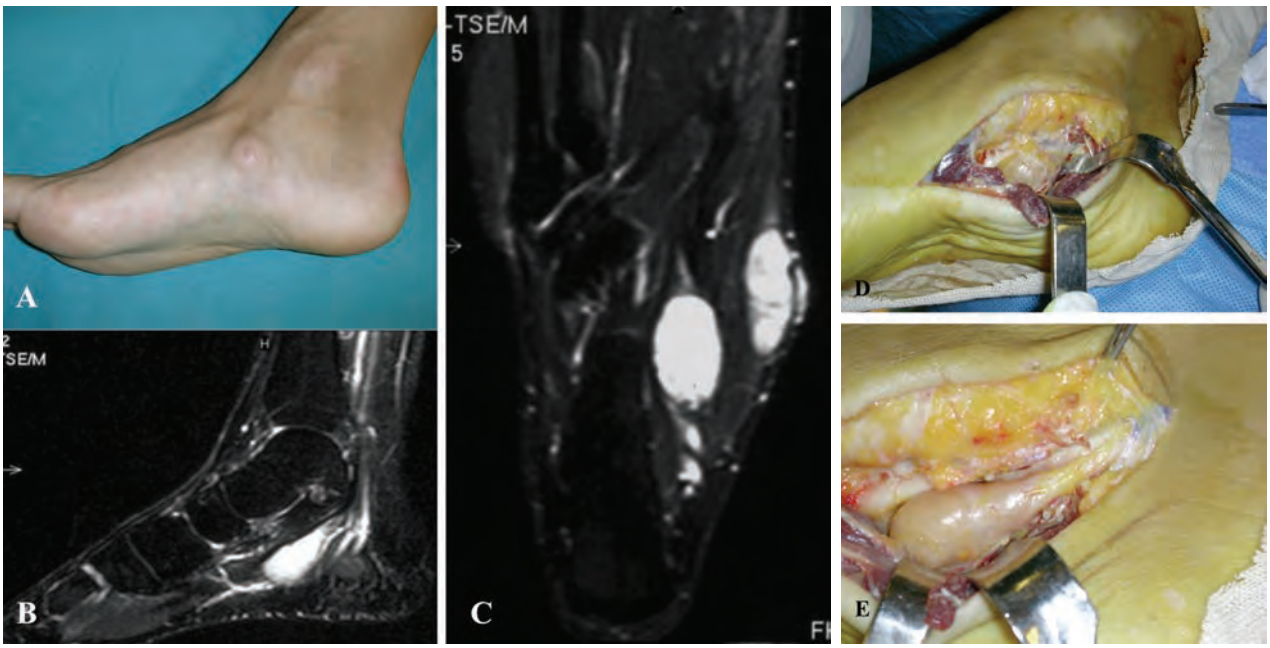

Figure 3. Case 4. A) Clinical photograph of the foot in lateral, non–weight-bearing view shows the presence of swelling on the medial aspect of the right foot. **B)** Sagittal T2-weighted MRI scan with fat suppression revealing an hyperintense homogeneous fusiform mass on medial aspect of the foot along the course of the medial plantar nerve. **C)** Coronal T2-weighted MRI scan with fat suppression high enhancement of the lesion. **D)** Intraoperative localization of the mass in the medial part of the foot. **E)** It is clearly shown the connection with the medial plantar nerve

Discussion

A search of the literature was done to identify patients who had been treated for their schwannoma of the foot. The English language and non-English language literature were searched in Pubmed using the «MeSH» "Neurilemmoma" and "Foot" with and without the terms «soft tissue tumors», «ankle», «benign» or «schwannoma» and in ISI Web of Knowledge database searching «schwannoma» as topic. The search was done using literature from 1996 to date (last two decades). The focus of each reference varied including: series of patients with soft tissue tumors of the foot, case reports and articles investigating specific forms of treatment of schwannoma. From the search of the literature we were able to find 51 cases of schwannomas of the foot from different articles and abstracts that were obtained and reviewed, and data were summarized in table 1 (4, 8-9, 11, 13-30).

Clinical observation. Schwannomas are soft tissue tumors that cause a variability of symptoms related to their location. Pain and/or numbness are the primary complaints in most of the cases, and the precise distribution of these symptoms allowed accurate localization of the tumor to a particular peripheral nerve, especially when they are superficial. Clinical examination is very important: the presence of lumps painful at the compression along the course of peripheral nerve it's a common finding. The clinical diagnosis is usually straightforward, but may be delayed for many years in a slow-growing schwannoma of the foot (13). In a study on 137 patients surgically treated for a PNST in a 16-years' experience, comparing 14 cases with PNST of the foot with those of other site, they found a significant female predilection and a smaller tumor volume (13). In our literature analysis, we found a 55% of cases affecting females, without a significant difference.

Radiographic features. Standard X-rays are often negative in soft tissue tumors. Ultrasonography and MRI examinations are valuable diagnostic tools that allow direct evaluation of mostly superficial-lying tumors. MRI is extremely useful in defining the extent of deep-seated schwannomas and for identification of the nerve of origin (6, 22). The lesion typically appears as ovalar shaped mass with iso-signal intensity relative to skeletal muscle on T1-weighted images and high signal intensity on T2-weighted images (6). However, the tumor stands out very well from surrounding tissues. In some cases, degenerative changes can be present, including cyst formation, calcification, hemorrage and fibrosis (6, 31). The main differential diagnosis includes synovial cyst, neurofibroma, low-flow venous malformations, lymphangioma or high grade sarcomas such as fibrosarcoma, leiomyosarcoma or synovial sarcoma (11, 14). MRI with gadolinium is useful to discriminate a schwannoma and a synovial cyst when a nerve connected to the lesion is not clearly showed (6). Plexiform neurofibromas are essentially pathognomonic of neurofibromatosis type 1 (NF1) and can be present at birth or develop within the first year of life (32). Differential diagnosis is important considering the risk of malignant transformation of the neurofibroma (4). Previous studies have found specific MRI features that can be used for differentiating between schwannomas and neurofibromas, even if the definite diagnosis should be confirmed by histological examination, especially in the plexiform variant (8). High grade sarcomas of the extremities could present with indolent growing or symptoms, mimicking benign soft tissue lesions (27, 33). In our experience, biopsy should be done with ultrasonography guidance through the surgical approach of definitive surgery, avoiding excisional biopsies as more as possible (34).

Treatment indications and complications. Asymptomatic patients with small tumors should be only monitored clinically. The reason to operate a patient with benign neurogenic tumors should be based on the balance between the risk and benefit of the surgery. Surgical excision is necessary for large tumors arising from major peripheral nerves in the extremities and in case of compressive symptoms (35). In the foot, also a small schwannoma affecting the plantar aspect of the foot become symptomatic during walking and jumping (as reported in our case 1 and 2) (14). Surgery consists of excision or intracapsular enucleation of the lesion after incision of the epineurium, which allows sparing of the parent nerve owing to its eccentric location, preserving the neurological function (14). It is important to expose adequately the affected nerve with sufficient proximal and distal margin. The exposure will allow for exact visualization of the tumor and for intraoperative nerve stimulation and monitoring.

Table 1. Schwannoma of the foot. Systematic review of the literature from 1996 to 2017

Author	Year	N. pts	Age	Gender	Nerve or site	NF	Variant	Treatment	Complications	Function or outcome
Ozdemir et al [15]	1997	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ikushima et al [16]	1999	1	8	M	Heel	-	Plexiform	Excision	-	Good
Bakotic et al [17]	2001	8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Odom et al [18]	2001	1	74	F	MP nerve	-	-	Excision	-	Good
Still et al [19]	2001	1	55	F	MP nerve	-	-	Excision	-	Good
Torossian et al [20]	2001	1	30	M	Heel	-	-	Excision	Need of flap reconstr.	Good
Mott et al [21]	2003	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mangrulkar et al [22]	2007	1	37	M	Foot (large mass)	-	-	Excision	-	LR (9 mos)
Boya et al [23]	2008	1	20	M	TP nerve	-	-	Excision	-	Good
Kwon et al [24]	2009	1	72	F	MP nerve	-	-	Excision	-	Good
Carvajal et al [13]	2011	1	44	F	Foot	-	-	Excision	-	Good
		1	78	F	Hindfoot	-	-	Excision°	-	Good
Jacobson et al [9]	2011	1	65	M	Midfoot	-	Plexiform	Excision	-	Good
Milnes et al [25]	2012	1	73	F	PT nerve	-	-	Excision	-	Good
Azevedo et al [26]	2013	5	n/a	n/a	n/a	-	-	Excision	n/a	LR-
Hallahan et al [27]	2014	1	54	F	PT nerve	-	-	Excision	Axonal tibial neuropathy	LR-
Kallini et al [28]	2014	1	25	M	Heel	-	-	Excision	n/a	n/a
Kellner et al [29]	2014	1	n/a	n/a	PT nerve	-	-	Excision	n/a	n/a
		1	n/a	n/a	PT nerve	-	-	Excision	n/a	n/a
		1	n/a	n/a	Sural nerve	-	-	Excision	n/a	n/a
Li et al [8]	2014	1	19	F	CPD nerve	-	Plexiform	Excision	-	Good
Mohammed et al [4]	2014	1	38	F	Heel subcutaneous	-	Plexiform	Excision	-	Good
		1	11	M	Midfoot	-	Plexiform	Excision	-	Good
Ruggieri et al [11]	2014	14	n/a	n/a	Hindfoot (6) Midfoot (8)	n/a	n/a	n/a	n/a	n/a
Nishio et al [14]	2015	1	32	F	PT nerve	-	Plexiform	Excision	-	Good
Min et al [30]	2015	1	38	M	MP nerve	Type III*	-	Excision	-	Good

NF: Neurofibromatosis; LR: local recurrence; CPD: Common Plantar Digital nerve; PT: Posterior Tibial; MP: Medial Plantar; n/a: not available;
° Recurrent lesion * Schwannomatosis has been considered as Type III NF

Obviously, the use of intraoperative magnifying glass and a gentle manipulation of the nerve, help to preserve the continuity and the function of the nerve. The patient should be informed about a possible transitory partial loosening of sensory or motor function of the nerve, as happened in our case 1.

Outcome. Adequate surgical excision of schwannomas in the foot and ankle is associated with minimal postoperative morbidity. Local recurrence is rare even if it is not an uncommon finding associated with plexiform variants (13, 36). It has been attribuited to incomplete resection, a focal lack of thick encapsulation, and irregular, finger-like tumor growth (9, 13). However recurrent schwannomas can be successfully treated with revisional surgery although the small sample size reported in literature (13, 22). Patients with identified plexiform schwannomas should be educated about the risk of recurrence. Malignant transformation of schwannomas is extremely rare and has only be reported in less than 15 cases in literature, usually associated with NF-2, Carney complex I and schwannomatosis (4-5).

Conclusions

Schwannoma rarely affect the foot. We have described four cases with different localizations: between the 2nd and 3rd metatarsal, between the muscle quadrauts of the sole and flexor brevis of the toes and under the lateral malleolus. MRI is a clinically useful modality in the evaluation and detection of deep-seated schwannoma, even if not always pathognomonic. A complete workup and examination will lead to the ideal diagnosis and treatment. Biopsy with histological examination should be performed in doubtful cases. Surgical excision with careful dissection from the nerve, seems to be an acceptable treatment for this peculiar condition affecting the foot.

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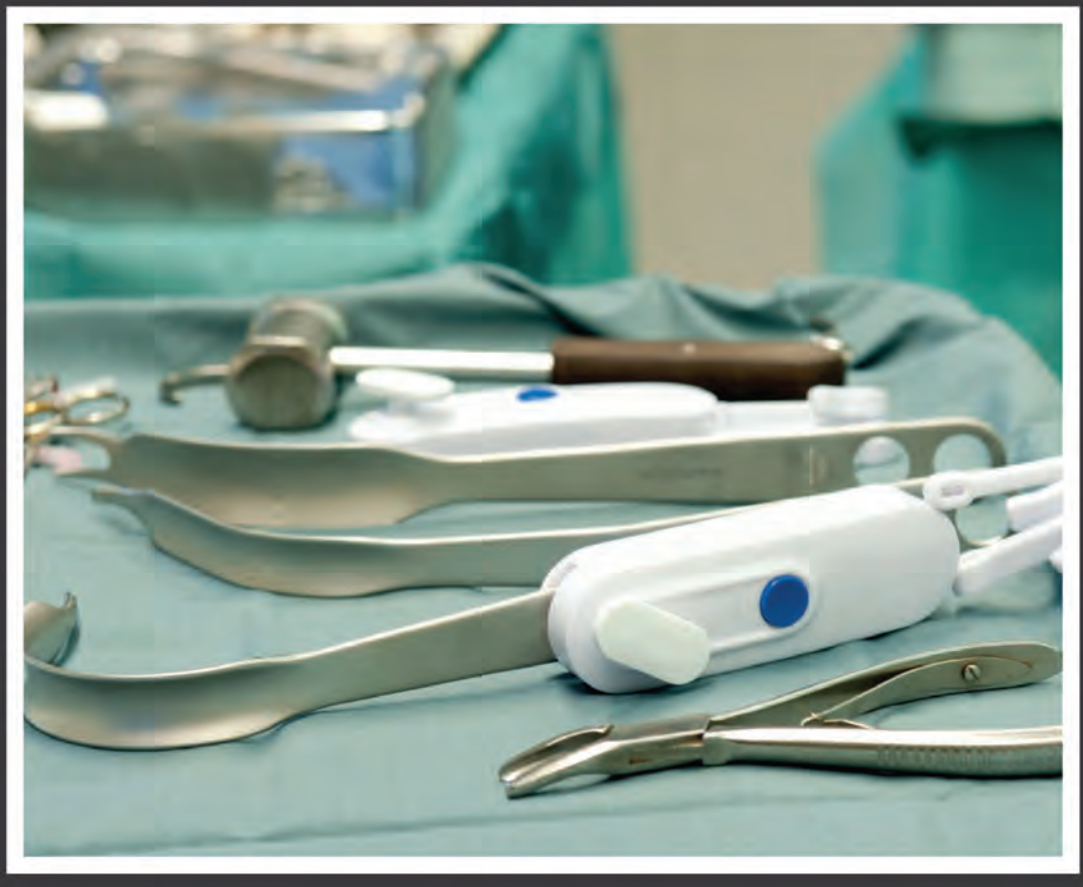

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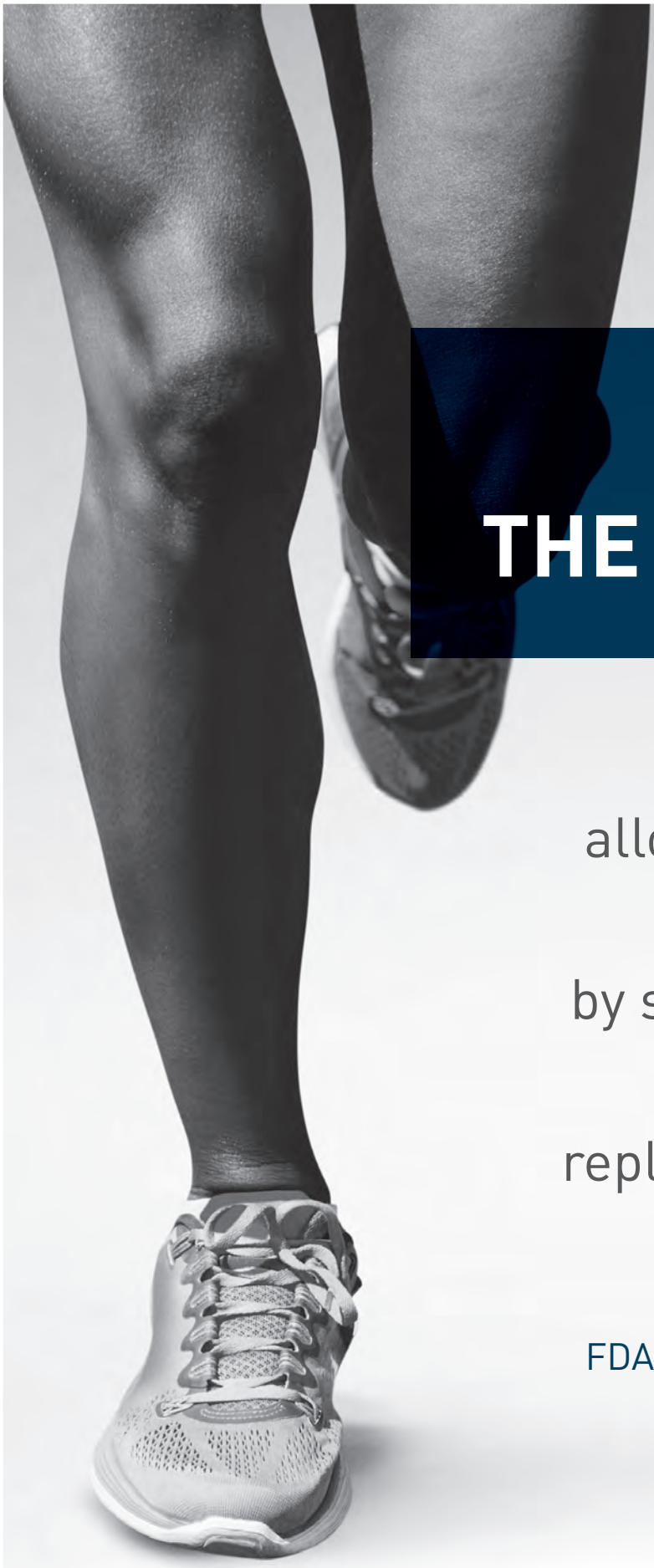

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