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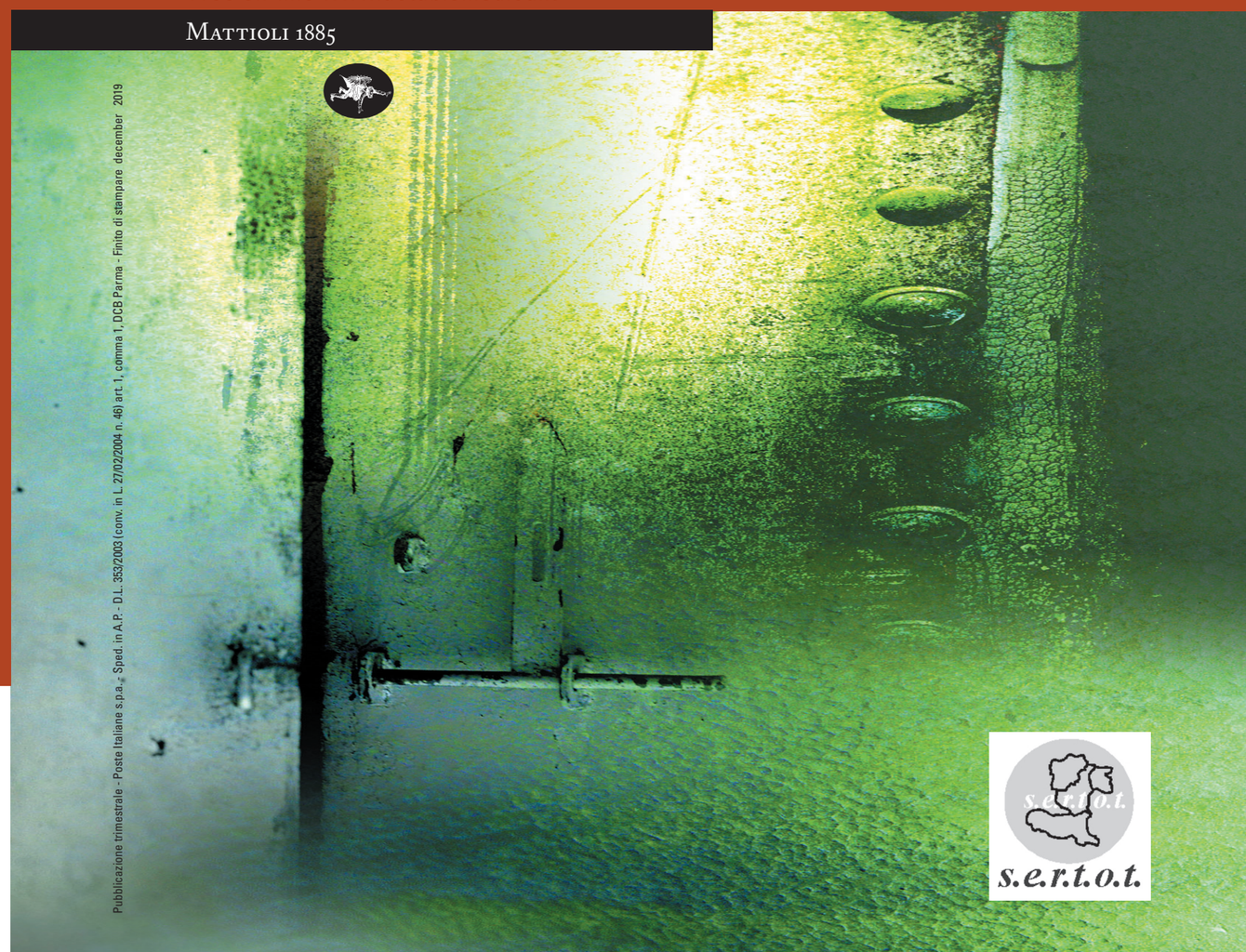

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Foreword

Dear Members,

it is with great happiness that I introduce the volume 2-2019 Acta Biomedica Supplement - Advances in Orthopaedics, Traumatology and Rehabilitation - SERTOT. The vitality of a Scientific Society is also assessed by its ability to regularly publish scientific papers. Consequently Our Society, also this year, will produce two issues that are focused on different orthopaedics and traumatologic topics. SERTOT has always stimulated their members to send articles to the magazine, even if the time is always shorter in terms of research. For these reasons I am very happy that, in this circumstance, contributions have arrived particularly numerous, thus confirming how SERTOT Members and not only, while publishing in magazines of greater prestige, do not give up to scientifically feed our Society and claim its future continuity. A special thanks to the Deputy Editors Francesco Pogliacomi and Paolo Di Benedetto for the personal commitment and passion dedicated to the magazine.

Sincerely

Enrico Vaienti

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Review

Post-operative periprosthetic humeral fractures after reverse shoulder arthroplasty: a review of the literature

Gianluca Canton[1], Francesco Fazzari[1], Roberto Fattori[1], Chiara Ratti[1], Luigi Murena[1]

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Summary. *Background and aim of the work:* Post-operative periprosthetic shoulder fractures incidence is gradually raising due to aging of population and increasing of reverse total shoulder arthroplasty (RTSA). Management of this complication represents a challenge for the orthopedic surgeon. Aim of the present study is to critically review the recent literature about epidemiology, risk factors, diagnosis, management and outcome of post-operative periprosthetic humeral fractures occurring on RTSA. *Methods:* A systematic search of Embase, Medline and Pubmed was performed by two reviewers who selected the eligible papers favoring studies published in the last ten years. Epidemiology, risk factors, diagnostic features, clinical management and outcome of different techniques were all reviewed. *Results:* 31 studies including reviews, meta-analysis, case reports, clinical and biomechanical studies were selected. *Conclusions:* Correct clinical management requires adequate diagnosis and evaluation of risk factors. Conservative treatment is rarely indicated. Locking plate fixation and revision arthroplasty are both valuable treatment methods. Surgical technique should be chosen considering age and functional demand, comorbidities, fracture morphology and location, bone quality and stability of the implant. Given the correct indication all surgical treatment can lead to satisfactory clinical and radiographic results despite a relevant complication rate. (www.actabiomedica.it)

Key words: periprosthetic shoulder fractures, RTSA, complications, management, humeral fracture

Introduction

Indications for RTSA increased over time from cuff tear arthropathy to include many other conditions that were difficult to treat with anatomical shoulder arthroplasty, such as acute proximal humerus fracture (Neer 3,4), chronic locked dislocation, immunological arthritis (in particular Reumathoid Arthritis, RA), proximal humeral fracture sequelae, failed primary shoulder arthroplasty and tumors (1, 2).

In recent years periprosthetic shoulder fractures became a growing problem due to aging of general population and to the increase in reverse total shoulder arthroplasty (RTSA) implants (3, 4).

RTSA complication rates are in a range between 19% to 68% and include principally scapular notching (50% - 96%), neurological injuries (1%-4%), infections (1%- 15%), instability (2%-31%) and periprosthetic fractures (1%-20%) (5-7).

Fractures include the greater or lesser tuberosity, metaphyseal portion or surgical neck, proximal humeral diaphysis, and the mid- and distal diaphysis. Advanced age and comorbidities often characterizing periprosthetic shoulder fracture patients add to the intrinsic technical difficulty in treating these injuries. Therefore, clinical and surgical management of these lesions can be a challenge for the orthopedic surgeon. Aim of treatment should be early functional recovery and prompt fracture healing minimizing the risk of complications. Aim of the present review is to report a summary of literature evidence about epidemiology, risk factors, diagnosis, management and outcome of post-operative periprosthetic humeral fractures after RTSA.

Methods

Two of the authors (FF and RF) independently reviewed studies by a systematic search of Embase, Medline and Pubmed using various combinations of the terms "periprosthetic, shoulder", "shoulder arthroplasty, fracture", "periprosthetic, fracture", "shoulder arthroplasty, complication", "RTSA, fracture", "humeral fracture in RTSA". The two authors screened the titles and abstracts of the citations identified independently and in duplicate, and acquired the full text of any article that either judged potentially eligible, favoring studies published in the last ten years. Epidemiology, risk factors, diagnostic features, clinical management and outcome of different techniques were all reviewed. Disagreements were resolved by discussion.

Results

A total of 31 studies were selected, including reviews, meta-analysis and clinical series. Case reports and small case series reporting about complications and very uncommon events were also included.

Discussion

Epidemiology

Introduction of reverse shoulder arthroplasty has improved treatment of patients with glenohumeral arthritis or prior failed shoulder arthroplasty associated with rotator cuff disorders in addition to high complex pattern proximal humeral fractures and inveterate dislocation.

Consequently, the utilization of RTSA is increasing, with a reported incidence of 33% in a recent epidemiological study by Schairer et al.(7) in primary shoulder arthroplasty. In USA the use of RTSA was approved by FDA since 2004 with approximately 10.000 RTSA performed in 2007 with a growing number of 30.000 in 2012 (11).

However, periprosthetic humeral fractures are relatively rare and there is limited information in the literature regarding such injuries.

Nonetheless, these fractures became a growing problem in recent years. The reasons of this trend probably reside both in aging of the general population, with several comorbidities including osteoporosis and higher risk of fall to the ground and in the growing number of RTSA (11).

The reported incidence in the USA reaches between 0,6 to 3% for RTSA, changing to 1,6 to 2,3% if all shoulder arthroplasties are considered. A retrospective cohort study using the data from the Mayo Clinic Medical Center Total Joint Registry (1976-2008) identified a postoperative humeral fractures rate of 0.9% (8-10).

Risk Factors

Risk factors can be divided in patient related and implant related. The main patient related risk factor for periprosthetic shoulder fracture is advanced age, particularly because of its association with higher risk of fall to the ground and with osteoporosis, which may both be considered as independent risk factors. Nonetheless, in the last years mean age of periprosthetic fracture patients notably raised, with a reported mean age of 80 years in 2018, resulting higher than the reported mean age in 1994 (71 years) (12, 13). Medical conditions associated to ambulation instability and/or to higher risk of fall as cardiac and neurologic pathologies may all be considered as risk factors. Chronic use of osteopenia inducing drugs such as corticosteroids or any other medical condition affecting bone quality may also be identified as risk factor. Moreover, bone quality is a critical factor to be considered for conservative treatment versus surgical treatment.

Other medical conditions as diabetes may act both as risk factor for fracture and as factors negatively affecting outcome. Diabetic patients may indeed be considered at risk for both periprosthetic fracture because of risk of fall due to hypoglycemia episodes and postoperative infections. Moreover, the same patients may be at risk for unfavorable outcome and complications because of immunological, vascular and neurologic peripheral compromise.

Epidemiologic data identify rheumatoid arthritis as a major risk factor, associated to about half of all the periprosthetic shoulder fracture cases described in the literature (14, 15).

The implant related risk factors include revision surgery, over-reaming or using an oversized broach in

the humeral component preparation, humeral deformity, and excessive soft tissues tightness coming from errors in bone cuts or components size (16).

Diagnosis

In most cases periprosthetic shoulder fractures diagnosis is straightforward, based on clinical suspicion that should always arise in case of trauma occurring to a prosthetic joint.

Radiographic evaluation is important to identify potential component loosening. A Grashey view of the glenohumeral joint and a true axillary view to assess for humeral head subluxation and glenoid component loosening should be better obtained. Images should include orthogonal views of the fracture.

A CT scan is usually diagnostic in doubt cases (classification type) and might be useful for preop planning.

Classification

Fractures can be first of all divided in intraoperative fractures (59%) and postoperative fractures (41%) (17).

The first classification was developed by Wright and Cofield and was a classification system simply based on the location of the fracture relative to the tip of the humeral prosthesis. This classification was originally created for post-operative fractures and it is limited to those occurring near the tip of the humeral stem. Type A fractures occur at tip with proximal extension greater than 1/3 of the stem length. Type B fracture also occur about the stem tip, with less proximal extension. Type C fractures occur distal to stem tip and are considered humeral shaft fractures (18). Non-operative treatment is often limited to type A and well aligned type C fractures.

Later Campbell et al. (19) defined four categories related to the fracture site: (A) tuberosities region; (B) metaphyseal portion or surgical neck; (C) proximal humeral diaphysis; and (D) mid- and distal humeral diaphysis. This type of classification results more adequate for intra-operative fractures.

Groh et al. (20) distinguished Type I fractures as occurring proximal to the tip of the prosthesis; Type II extending from the proximal part of the humeral shaft to beyond the distal tip of the stem; and Type III as fractures lying distal to the tip of the prosthesis.

In 2018 Kirchkoff et al (21) developed a more complex classification including three subclassifications: location of the fractures (acromial, glenoidal and humeral), type of fractures (tuberosities, spiral, oblique, distal) and implant stability (stable, loose). They also proposed a simple algorithm with these three classification subtypes to suggest the treatment (ORIF vs conservative or revision).

Treatment

Correct indication for treatment of these complex lesions can differ case by case. The variables influencing the decisional process are many: general health status and functional demand of the patient, fracture location and morphology, bone quality, and implant stability.

Surgical experience of the treating surgeon should also be considered (22-23).

Aim of surgical treatment should be functional recovery with respect to pre-injury activity level, minimizing complications. Healing is generally considered when the patient fully recovers activities of daily living without pain, associated with radiographic healing.

Athwal et al. (16) reported that the first treatment for periprosthetic humeral fractures (PHF) begins with prevention and that special care should be taken in patients with documented risk factors (osteopenia, RA, revision surgery, etc.) to avoid increasing stress on the humerus.

Treatment modalities for periprosthetic shoulder fractures range from conservative treatment to ORIF (open reduction internal fixation) and revision arthroplasty. In case of non-displaced or minimal displaced fractures with transverse or spiroid morphology conservative treatment may be indicated: splint mobilization in neutral rotation or abduction is preferable to avoid diaphyseal rotational malunion (24).

In displaced periprosthetic fractures conservative treatment may be indicated only in low functional requirements patients or in the presence of severe comorbidities (21).

Osteosynthesis can be done using various approaches: anterior shoulder approach (deltopectoral

approach), posterior or lateral approach. The latter two enable visualization and protection of radial nerve, with different advantages and indications related mostly to fracture location. In particular, posterior approach is generally preferred for more distal fractures and deltopectoral or antero-lateral approaches for proximal/mid third fractures. Identification of the radial nerve is always needed to allow its protection when diaphyseal cerclages have to be performed.

Fixation can be done with plates and screws, plates and cerclages, and plates and screws associated with cerclages. Locked screws promote rotational control, and cerclage increases the stability of the construct at the stem level.

Angelini et al. (25) suggest cerclage wires to function as a temporary tool for reduction during surgery and that when correctly applied the damage to bone blood supply is less than expected. Cameron et al. (26) reported that when treating unstable diaphyseal periprosthetic humeral fractures with well-fixed components, a heavy plate with proximal cerclage wires and distal screws is the treatment of choice (Figure 1). The plate should overlap the tip of the prosthesis by two cortical diameters to avoid the creation of a stress riser.

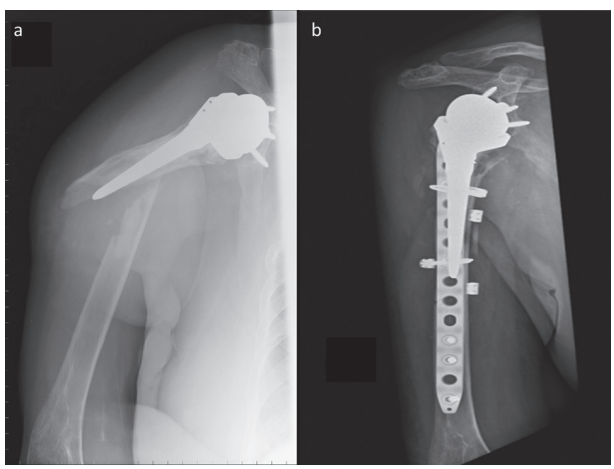

Figure 1. A 78-year-old woman, right-handed, fell to the ground 10 years after cemented RTSA implantation for right shoulder cuff tear arthropathy. a) pre-op radiograph showing periprosthetic humeral fracture. b) post-operative radiograph showing fracture reduction and fixation with 4.5mm 14 holes locking plate with cerclages and screws. Clinical healing with full activities of daily living recovery was documented at 18 months

There seem to be no significant differences in the rate of periprosthetic humeral fractures between uncemented RTSA and cemented RTSA (27).

Based on the experience with Vancouver B3 hip fractures, Thes et al (28) described an internal fixation technique for periprosthetic humeral fractures in patients with severe osteoporosis and bone loss. The authors describe a technique where the fracture is surrounded by two hemicylinder of tibial allografts, placed around the humerus to create a "sarcophagus" system. The allograft was as long as possible for optimal mechanical stability, without creating impingement with the glenoid and the elbow. Final fixation of the allograft is obtained with two cerclage wires.

Revision surgery should always be considered when humeral component loosening is detected. Described radiographic signs of loosening are the presence of a radiolucent line measuring >2 mm in three or more zones around the perimeter of the stem or when a change in the relative position on the stem is found on serial radiographs (29). In these cases, analyzing previous radiographs is crucial for treatment planning.

In post-operative management, all patients should be immobilized in a shoulder sling. Shoulder flexion and abduction should be limited to 90° for six weeks post-operatively. Clinical and radiological controls should be performed at six weeks, 12 weeks and 12 months after operative treatment. Periprosthetic humeral fractures healed in literature reports at a mean time of 18 weeks (range 16-20) with a non-union rate of about 13% (30).

The overall complication rate is reported to be between 20% to 40%. Non-union or malunion are especially associated with conservative treatment. Loss of shoulder motion is the primary reason for an unsatisfactory result (based on the Neer criteria).

Other complications included neurapraxias (axillary nerve or radial nerves, 6-25% reported), frozen shoulder, and superficial infection (30, 31).

Clinical outcomes are usually evaluated using a visual analog scale (VAS) for pain, American Shoulder and Elbow Surgeon (ASES) score, and subjective shoulder value (SSV). Active ROM (range of motion) is normally evaluated in terms of forward flexion, abduction, and external rotation with the arm at the side and internal rotation with the arm at the back. Ra-

diological outcomes should be assessed by serial plain radiographs.

Conclusions

Periprosthetic shoulder fractures are a growing clinical problem. Correct clinical management requires adequate diagnosis and evaluation of risk factors. Conservative treatment is rarely indicated. Locking plate fixation, cerclages and revision arthroplasty are all valuable treatment methods. Surgical technique should be chosen considering age and functional demand, comorbidities, fracture morphology and type, bone quality and stability of the implant. Given a correct indication all surgical treatment can lead to satisfactory clinical and radiographic results despite a relevant complication rate.

Compliance with ethical standards

Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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Review

Surgical or conservative treatment in ARGP syndrome? A systematic review

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Summary. *Background and aim of the work:* The rectus-adductor syndrome is a common cause of groin pain. In literature the adductor longus is reported as the most frequent site of injury so that the syndrome can be fitted into the adductor related groin pain (ARGP) group. The aim of this study was to define what is the best treatment between surgical and conservative in athletes affected by ARGP in terms of healing and return to play (RTP) time. *Methods*: A systematic review was performed searching for articles describing studies on RTP time for surgical or conservative interventions for ARGP. A qualitative synthesis was performed. Only 10 out 7607 articles were included in this systematic review. An exploratory meta-analysis was carried out. Due to high heterogeneity of the included studies, raw means of surgery and conservative treatment groups were pooled separately. A random effects model was used. *Results*: The results showed quicker RTP time for surgery when pooled raw means were compared to conservative treatments: 11,23 weeks (CI 95%, 8.18,14.28, p<0.0001, I^2=99%) vs 14,9 weeks (CI 95%, 13.05,16.76, p<0.0001, I^2 = 77%). The pooled results showed high statistical heterogeneity (I^2), especially in the surgical group. *Conclusions*: Surgical interventions are associated with quicker RTP time in athletes affected by ARGP, but due to the high heterogeneity of the available studies and the lack of dedicated RCTs this topic needs to be investigated with dedicated high quality RCT studies. (www.actabiomedica.it)

Key words: rectus-adductor syndrome, groin pain, athletes, return to play

Introduction

Groin pain is an ambiguous clinical entity (1-5). The topic itself is still debated, with great lack of consent especially regarding the classification and therapeutic approach (6,7). Because of multiple definitions that are reported in literature (mostly improperly used) a terminological clarification seems to be necessary.

Groin pain is defined as an algic sensation in the groin area, which can underlie different pathologies, not necessarily musculoskeletal-related and sometimes in association (8). The pain is usually unilateral and localized to the pubic tubercle or to the medial compartment of the thigh, eventually irradiated to the adductor or abdominal muscles, to the pelvic floor and the genital area thus making the diagnostic process very difficult (8-10).

The rectus-adductor syndrome is one of the major causes of groin pain and it can be defined as the insertional tendinopathy of rectus abdominis and/or the adductors of the thigh and eventually associated with pubic osteoartropathy (8). The syndrome is typical of male athletes between 20 and 30 years of age which are involved in high intensity team sport, such as soc-

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cer, hockey, basketball and football (9,11,12). It is reported to have an incidence between 2,5-3% of all the sport related pathologies (13,14). The etiopathogenesis seems to be linked both to the imbalanced contraction of the two main dynamic stabilizers of the anterior pelvic area - the so-called muscle imbalance syndrome of the groin - and microtraumas associated to functional overuse of the same muscles: the rectus abdominis and the adductors of the thigh (15-19). Besides, the adductor longus is reported as the most frequent site of injury in several articles (20-22) which highlighted that the susceptibility of this muscle to injury can be traced to his peculiar anatomy and vascular supply from the deep femoris artery. Taking into account the systematic video analysis conducted by Serner et al. (23) on a series of acute adductor longus injuries in soccer players, most of them were non-contact, and extremely heterogeneous in term of pathogenesis, including both close and open chain actions such as change of direction, kicking, reaching the ball and jumping. According to the authors, the fast activation of the adductor longus in occasion of muscle lengthening seems to be a major mechanism of injury.

The recent work by Schilders et al. (24) proposed an alternative anatomic concept, trough the demonstration of a direct connection between pyramidalis and adductor longus muscle, renamed by the authors "pyramidalis-anterior pubic ligament-adductor longus complex". The systematic dissection of 7 male cadavers showed that the rectus abdominis is not attached to the adductor longus, reducing its role in acute adductor longus injury. These findings may have future implication into the diagnostic and therapeutic management of the adductor longus acute strain.

Although frequently reported in literature, Sports Hernia and Athletic Pubalgia are both two misleading terms (6,25,26).

Sports Hernia (or Sportman's Hernia) is referred to an occult hernia caused by weakness or tear of the posterior inguinal wall leading to groin pain in occasion of training and competition, not interfering with every day life (25).

Athletic Pubalgia is an extremely generic term that interests multiple pattern of injury such as the deficiency of the posterior abdominal wall/inguinal floor (Sports Hernia), the rectus tendon /rectus-adductor aponeurosis complex strain or tear and the inguinal and/or genital neuropathies (9).

Several authors proposed to move away from the use of both these terms, since their lack of specificity about the underling pathology and the anatomical site of injury: a new standardized and more organ-specific classification seems to be needed (6,15).

A deep effort to set up an unified classification system for groin pain was taken in the "Doha agreement meeting on terminology and definition in groin pain in athletes" with the proposal of a new classification focused on the anatomical site of injury and clinical findings (6).

Following this statement, the rectus adductor syndrome seems to be more properly included in the ARGP group since the major involvement of the adductors of the thigh with pain and tenderness.

The diagnostic process is based on an accurate history-taking, the clinical evaluation and instrumental investigations, which allow the morphological description of the injury (26-27).

The Italian Consensus, suggested to use a group of specific tests for adductor, abdominal wall muscle and hip joint in order to evaluate the tenderness of the involved structures (28,29).

The instrumental investigation mainly relies on conventional radiography, ultrasonography and MRI which is considered the gold standard exam for soft tissue evaluation and it allows to detect the presence of peculiar markers (30-32).

The therapeutic management of ARGP is challenging and it is usually conservative at first. It requires a multidisciplinary approach including rest, physical exercise, shock wave therapy, nonsteroidal anti-inflammatory drugs and platelet rich plasma eco-guided injections, eventually in association (26,33-35).

In case of failure of conservative management and significant limitation of the athletic performance, surgery may be considered (9). It usually consists of adductor tenotomy and/or reinforcement of the posterior wall of the inguinal canal; many techniques are described in literature (36-52).

Postoperative rehabilitation needs to be gradually progressive and focused on muscle strengthening, balance and flexibility (9).

The aim of this study was to define what is the

best treatment between surgical and conservative in athletes affected by groin pain and in particular ARGP syndrome in terms of healing and return to play (RTP) time.

Materials and methods

In order to compare RTP time between surgical and conservative interventions in the treatment of ARGP syndrome in athletes, a selective systematic review of the literature was performed using PubMed, Embase, Scopus, Web of Science, Cochrane Library, Google Scholar and CINHAL searching for specific articles. All mentioned databases were screened up to 30th April 2019.

The PRISMA (53) statement was followed for this systematic review and meta-analysis.

The following list summarized the applied PICOS criteria for inclusion and exclusion of studies both in the systematic review and meta-analysis.

P (Population): Athletes with groin pain;

I (Intervention): All types of conservative or surgical intervention on adductor muscles;

C (Comparison): All types of control/comparison, even no control/comparison;

O (Outcomes): RTP time;

S (Study design): Randomized controlled trials (RCT), non-randomized clinical trials and prospective cohort studies.

After searching electronic databases, 7607 articles were identified and collected. When duplicates were removed, 3163 articles remained for the screening process. After an evaluation based on the assessment of their contents, 3152 articles were excluded. Then, only 12 articles underwent full-text screening and 2 of them were excluded because of no RTP time was reported. Finally, 10 articles were included both in the qualitative and quantitative synthesis (Figure 1).

Results were screened by three authors (PG, PB, ML). Data were manually extracted by a single investigator (PG) from included articles and then summarized in table 1.

The quality of the included randomized controlled trials (RCT) was assessed following the JADAD score dedicated tools (54). The quality of the included non-randomized trials was assessed following the criteria

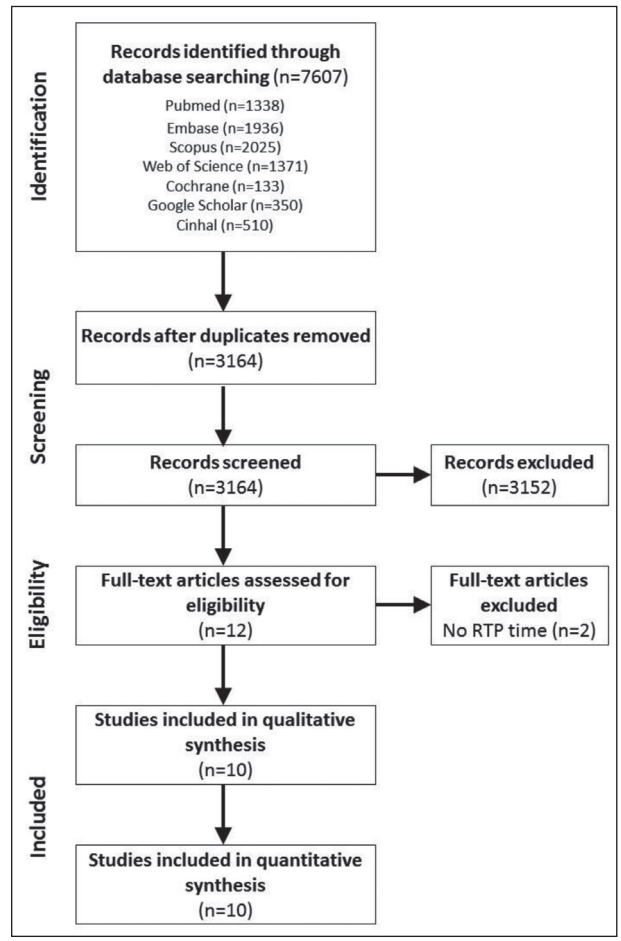

Figure 1. PRISMA flowchart of the systematic review and meta-analysis

of the NIH dedicated tools (55). Due to high heterogeneity of the included studies, raw means of surgery and conservative treatment groups were pooled separately. When mean standard deviations (SD) were not reported, they were estimated from reported or standard errors with proper statistical tools (56-57). When only sample medians, as well as minimum and maximum values, first and third quartiles were available, sample means and standard deviations were calculated with validated formulas accepting the assumption that the original data distribution was normal in order to maximize retrievable data and minimize publication bias (58). Considering high heterogeneity of included studies, a random-effect model was adopted to better estimate overall size effects.

Only 10 out 7607 articles screened were included in the systematic review. Data collected were summa-

rized in table 2 and discussed to obtain a qualitative synthesis. An exploratory meta-analysis was carried out using Rstudio software (V.1.2.1335) as a semi-quantitative analysis. Included studies were heterogeneous in terms of design, population, intervention and comparison, so it was necessary to consider the different groups of interventions as separated observational prospective studies, in order to achieve the best possible homogeneity. Two meta-analysis for surgical treatment and conservative treatment were then performed.

I2 was used as a measure of consistency. I2 values of 25%, 50%, and 75% were interpreted as representing small, moderate and high levels of heterogeneity.

Results

Of the reviewed studies 2 were RCTs and 8 were NRSs. Among the NRSs, 2 were clinical trials and 6 were prospective.

The total number of athletes included was 703. Of these, 4 (0.56%) were female (30,60,1) and the remaining 699 (99.44%) male.

The basic pathology was called "athletic groin pain/athletic pubalgia" in 3 studies (62-64) and in 4 "adductor-related groin pain". Dojcinovic et al. (37), Harr et al. (30) and Sebecic et al. (1), referred to the pathology as sports hernia and/or adductory tendinopathy. In particular in the study by Harr et al. (30) reference was made to the aetiological sharing of the rectus abdominis muscle.

The most practiced sport was football (327 athletes-46.5%), followed by Gaelic football (177-25.17%), hurling (36-5.12%), rugby (23-3.27%), the race (13-1.84%), hockey (8-1.13%) and lacrosse (3-0.42%). Ice speed skating, athletics, squash and basketball accounted for 0.28% each. Other sports (baseball, cycling, horseback riding, football, handball, tennis, triathlon and refereeing) together made up 1.13%. For 100 athletes (14.22%) the sport practiced was not specified.

Two-hundred and seventy-six athletes underwent surgery and 274 (99.01%) returned to sport. Three-hundred and sixty-five athletes completed a conservative treatment program. Two-hundred and ninety-one (79.72%) returned to sporting practice. Sixty-two athletes (8.81%), whose totality belongs to the conservative treatment group, were excluded from the studies (Figure 2).

In 4 studies (30,1,37,62) the treatment was surgical. In all 4, in at least one intervention group, the adductor tenotomy was performed along with an abdominal wall repair technique. In 2 reports (1,37) the abdominal wall repair technique was performed exclusively in an intervention group. No tenotomy of the long isolated adductor alone was performed in any study.

The approach to tenotomy was open in 3 studies and percutaneous in one (62). The tenotomy was bilateral in 3 reports (1,37,62), unilateral in one (62) and in one (30) it was not specified.

The tenotomy was complete in 2 studies (1,37), partial in one (30) and in one (62) it was not specified.

Abdominal wall repair was performed with an open approach and without the use of mesh in all studies. The techniques used were hernioplasty according to Bassini simple or modified (63), or according to Shouldice (1,37) and the herniorrhaphy with suture of the defects of the external oblique and of the joint tendon fascia, previously released, with the ileopubic tract (30).

In two studies (1,37) neurolysis of the ileoinguinal nerve and resection of the genital branch of the genitofemoral nerve was associated.

Treatment was conservative in 6 studies. In all of these, in at least one intervention group, a training protocol was applied: in 3 Holmich protocol (35,60) and in the study by Yousefzadeh et al. (61) a variant thereof were done. In two reports, a training program focused on intersegmental control was planned (63,64).

Weir et al. (33) also added a standardized running program to the original Holmich protocol. This program was organized in 3 levels: slow travel, straight line shots and changes of direction.

The training program performed by Gore et al. (63) and by King et al. (64) was also divided into three levels. The first level included exercises of strength and intersegmental control. The linear stroke rehabilitation followed. The last level included exercises with changes of direction and the reacquisition of the ability to shoot at maximum intensity.

Table 1. Characteristics of studies included in the systematic review

First Author and date	Study design	Number of patients, sex	Sport	Intervention	Group 1	Group 2	RTPt (weeks)	Authors' conclusions	JS
Holmich et al. 1999	RCT	68 M	Soccer 54 NR 14	1) Holmich Protocol. 3 times per week for 8-12 weeks. Patients were allowed to ride a bicycle. After the first 6 weeks of treatment patients were allowed to jog in running shoes on a flat surface so long as it did not provoke groin pain. 2) Laser treatment with gallium aluminium arsen laser 1'. Stretching of adductor muscles, hamstring muscles, and hip flexors. 30" per muscle, 3 times. Transcutaneous electrical nerve stimulation for 30 min at painful area.	Intervention 1 30/34	Intervention 2 29/34	23/30 18,5 4/29 18,5	Y	3
Weir et al 2011	RCT	53 M 1 F	Soccer 37 Rugby 3 Running 3 Hockey 3 Speed skating 2 Squash 2 Tennis 1 Basketball 1 Handball 1 Track-and-fiel1	1) Holmich Protocol. 3 times per week for at least 8 weeks. During the first six weeks only cycling was allowed. At six weeks the return to running program was started. 2)Heat with paraffin packs for 10', manual therapy. Slow jogging or cycling for 5'. Stretches of the adductors of both legs for 30". Warm bath for 10'. After 14 days of stretching if no pain or discomfort was felt, same return to running program as in group1 was performed.	Intervention 1 22/25	Intervention 2 26/29	12/22 17.3±4.4 13/26 12.8±6	N	2
Dojcinovic et al. 2012	NRS	99 M	Soccer 79 NR 20	1) Shouldice technique, ilioinguinal nerve neurolisys and resection of the genital branch of genitofemoral nerve. 2) Complete bilateral adductor longus tenotomy.	Intervention 1 70/99	Intervention 1+2 29/99	24/29 13,4 (12-16) 5/29 11,6 (10-15) 70/99 4.23 (3-16)	U	5

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Table 1 ***(continued)*****.** Characteristics of studies included in the systematic review

First Author and date	Study design	Number of patients, sex	Sport	Intervention	Group 1	Group 2	RTPt (weeks)	Authors' conclusions	JS
G ore et al. 2018	NRS	64 M	Soccer 6 Gaelic Football46 Hurling 7 Rugby 5 NR 1	3-level rehabilitation program focused on inter-segmental control.	Intervento 64/64	Controllo: 50 M non infortunati	64/64 9,14 5.14-29.0	U	6
Harr et al. 2017	NRS	20 M 2F	NR 7 Running 7 Lacrosse 3 Football 1 Baseball 1 Triathlon 1 Track-and-field 1 Horse riding 1	Suture herniorrhaphy with adductor longus tenotomy.	Intervention 22/22		22/22 6–8	Y	4
King et al. 2016	NRS	205 M	Gaelic football 131 Hurling 29 Soccer 25 Rugby 15 Hockey 5	3-level rehabilitation program focused on inter-segmental control.	Intervento 163/205		150/163 9.9±3.4	Y	7
Sebecic et al. 2014	NRS	113 M 1 F	Soccer 91 NR 23	1) Modified Shouldice technique, ilioinguinal nerve neurolisys and resection of the genital branch of genitofemoral nerve. 2) Bilateral adductor longus tenotomy.	Intervention 1 83/114	Intervention 1+2 31/114	81/83 4,4 (3-16) 31/31 11,8 (10-15)	Y	3
Van der Donckt et al. 2003	NRS	41 M	Soccer 35 Running 3 Basketball 1 Ciclyng 1 Refereeing 1	1) Bassini's hernial repair with unilateral percutaneous adductor longus tenotomy. 2) Bassini's hernial repair with bilateral percutaneous adductor longus tenotomy.	Intervention 1 27/41	Intervention 2 14/41	41/41 27,6 (24-60)	Y	5

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Table 1 ***(continued)*****.** Characteristics of studies included in the systematic review

First Author and date	Study design	Number of patients, sex	Sport	Intervention	Group 1	Group 2	RTPt (weeks)	Authors' conclusions	JS
Yousefzadeh et al. 2018	NRS	17 M	NR 17	Holmich protocol. 3 times per week for 8-12 weeks. Patients were allowed to ride a bicycle. After the first 6 weeks of treatment patients were allowed to jog in running shoes on a flat surface so long as it did not provoke groin pain.	Intervention 14/17		11/14 14.2 (10-20)	Y	8
Yousefzadeh et al. 2018	NRS	18 M	NR18	Modified Holmich protocol, focused on "core stability", "elastiband". Stadardized running programm for 10 weeks.	Intervention 15/18		13/15 12.06±3.41	Y	8

Abbreviation: RTPt: return to play time; JS: Jadad Score; NR: not reported; RCT: randomized controlled trial; NRS: non randomized trial; M: male; F: female; Y: intervention is effective; N: intervention is not effective; U: it is unclear whether intervention is effective or not

In 2 studies (59,60) a multimodal rehabilitation approach not focused on active exercise was evaluated in an intervention group.

Exercise protocols were supervised by physiotherapists in 3 cases (59,61,62). In 2 articles (60,64) there was no supervision during the training program and in one (65) it was not specified.

Referring to the conclusions, in 7 reports (30,33,35,62,64) the respective authors considered the intervention effective, in 2 (37,63) the judgment was not clear and in one (60) the intervention was not considered effective.

The analyzed studies were characterized by high heterogeneity. It was therefore decided to perform a meta-analysis of proportions with the raw averages of the RTP time isolating the groups investigating the surgical or conservative treatment for the adductory component only between RCT and NRS. This allowed the semi-quantitative evaluation of the two approaches to assess which would guarantee shorter timescales for the return to competitive activity.

It's interesting to note, as two (62,64) among the mentioned studies, constituted the outliers of quantitative analysis so they were excluded.

From the meta-analysis of the studies investigating a conservative treatment a RTP average time of 14,91 weeks was observed(CI 95%, 13.05,16.76, p<0.0001, I^2 = 77%) (Figure 3).

Referring to surgical treatment the result showed a RTP average time of 11,23 weeks (CI 95%, 8.18,14.28, p<0.0001, I^2=99%) (Figure 4).

The qualitative synthesis seemed to highlight a more frequent return to sporting activity in subjects undergoing surgical treatment. However it was good to reduce the appropriateness and outcome of intervention considering that in 3 articles (62-64) the precise aetiology of "athletic groin pain" was not specified.

Quantitative synthesis suggested the superiority of surgical treatment over conservative in ensuring a faster return to sporting activity. The average RTP time of surgery was 11.23 weeks, compared to 14.9 weeks of conservative treatment.

Discussion and conclusions

Hip and pelvic lesions which determine groin pain are not infrequent and are often a challenge to manage, even for the most expert physicians.

Groin pain is the term commonly used to identify painful symptoms of the pubis and of the anterior pelvis, with possible irradiation towards the adductor,

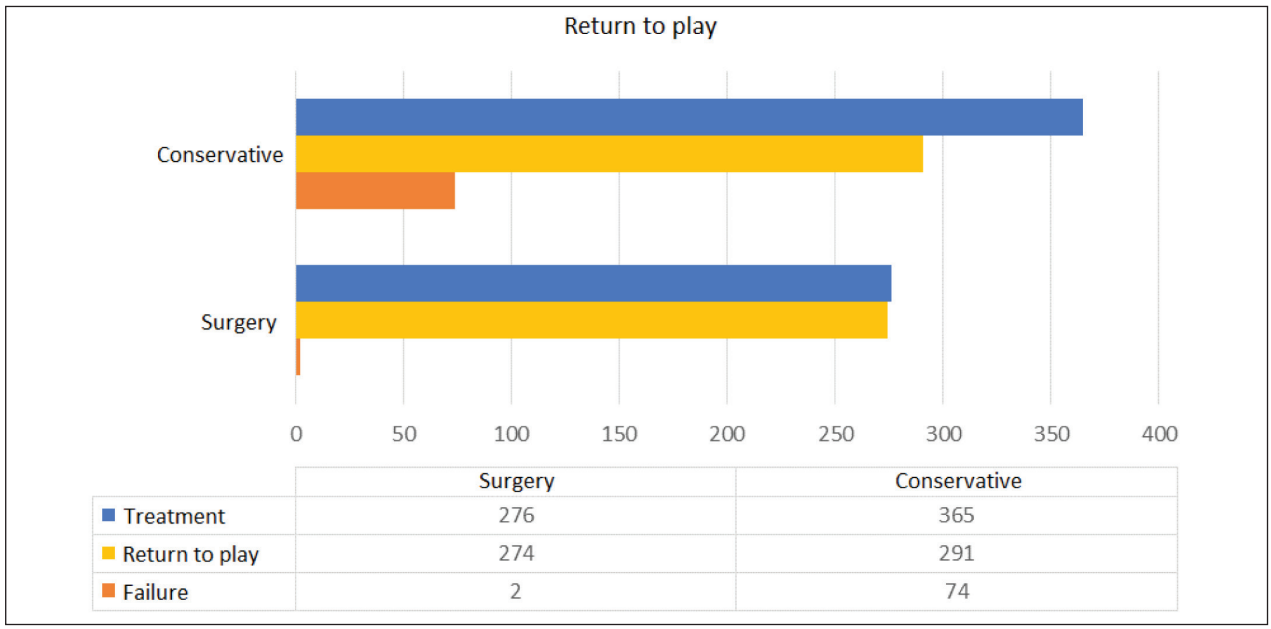

Figure 2. Graphic referred to intervention, return to sport and therapeutic failure of surgical and conservative treatment in the study population.
Blue = intervention (276 surgical; 364 conservative); Yellow = return to sport (274 surgical; 291 conservative); Orange = failure (2 surgical; 74 conservative)

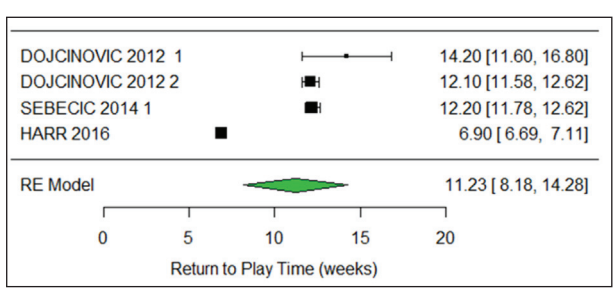

Figure 3. Forest plot referred to the meta-analysis about mean RTP time (in weeks) after surgery. Description: groups of intervention are reported in columns with author first name. Means and standard deviations are reported in columns and a random-effect model was adopted to better estimate overall size effects

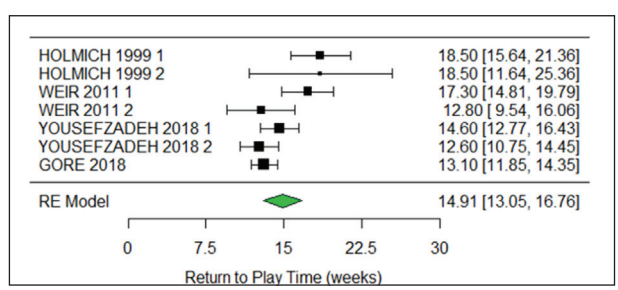

Figure 4. Forest plot referred to the meta-analysis about mean RTP time (in weeks) for conservative treatment. Description: groups of intervention are reported in columns with author first name. Means and standard deviations are reported in columns and a random-effect model was adopted to better estimate overall size effects.

abdominal muscles and crural arches. These symptoms cannot be considered a pathology; it would be more correct to speak of "groin pain related syndromes", that too often are simplistically and erroneously labelled "generic pubalgia". In literature there is not a definitive accordance on approach for groin pain, which is universally recognized, thus increasing misdiagnosis and incorrect treatments. This is confirmed in this review in which only few (n=10) reports have the characteristics of valid scientific studies.

Consequently, also in recent years many athletes, both professional and non-professional, have had to interrupt their career or sporting activity prematurely for an imprecise pain to the groin or pubis which was not adequately diagnosed and treated. In the past it was very frequent to encounter these symptoms in

high-level athletes at the end of their career; now, however, athletes of all ages, even adolescents, are being affected.

The rectus-adductor syndrome is one of the major causes of groin pain and it can be considered an insertional tendinopathy of rectus abdominis and/or the adductors of the thigh, more or less associated with pubic osteoarthropathy. Recently, Doha agreement meeting highlighted that the adductor longus is the most frequent site of injury so that this syndrome can be fitted into the ARGP group.

Nevertheless, the diagnosis is difficult and it remains a complex clinical reality. The debate involves every area of pathology, including anatomy. The difficulty in approaching this pathology depends also on the etymological discrepancies between the Italian (28,29) and Anglo-Saxon languages (65) therefore it is necessary a more universally shared nomenclature.

Literature is not clear also on its correct treatment in relation with RTP time.

Comparing the results of intervention of the proposed meta-analysis, it seems that surgery allows shorter time to return to sport activity than conservative treatment in athletes with ARGP syndrome. However, the strong heterogeneity of the available studies and the lack of dedicated RCTs make it impossible to draw definitive conclusions. This data must therefore be considered as suggestive of a potential superiority, which would deserve to be studied directly through quality RCTs.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Review

Osteoporotic distal femur fractures in the elderly: peculiarities and treatment strategies

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Summary. Distal femur fractures account for 4-6% of osteoporosis related fractures of the femur in the elderly population. They represent a relevant cause of morbidity and mortality in the geriatric population with a reported 1-year mortality reaching 30%. Non-displaced fractures or even displaced fractures in patients with high operative risk can be treated conservatively. However, operative treatment is the most widely accepted management option for displaced fractures. The advantage resides in early mobilization and weight-bearing, reducing risks related with a prolonged immobilization when compared with conservative treatment. On the other hand, the intrinsic difficulty of fixing an osteoporotic bone is a major concern. The presence of osteosynthesis devices or prosthetic implants in the femur can make the surgical treatment more challenging, sometimes limiting therapeutic options. Aim of the present paper is to review the most recent literature about osteoporotic distal femur fractures in the elderly, including periprosthetic and other hardware related fractures, to highlight current evidence on management options and related results as a guide for the daily clinical practice. (www.actabiomedica.it)

Key words: distal femur, fractures, elderly, osteoporotic

Introduction

Distal femur fractures account for 4-6% of fragility fractures of the femur, with an overall annual incidence of 4,5/100.000 in the general population (1). About 50% of these fractures affect patients over 70 years of age, being a relevant cause of morbidity and mortality in the geriatric population. A 6-months mortality rate of 16% is indeed reported, rising to 30% at 1 year. The presence of a total knee arthroplasty and of severe comorbidities is also related with increasing mortality rates in some literature reports (2-4).

Alike fractures of the proximal femur, early surgical intervention (within 48 h) of distal femur fractures is related with a decrease in mortality rates in the elderly population and allows to reduce complications rate associated with prolonged immobilization (1, 2, 5).

Most fragility fractures of the distal femur are due to low-energy trauma in patients with osteopenia or osteoporosis, predominantly women. The most common mechanism of injury is a direct axial load or, less frequently, the consequence of torsional or rotational forces applied to the lower limb (6, 7).

The fracture is predominantly located at the distal metaphysis of the femur and the most typical deformity is represented by shortening associated with extension and varus deviation of the distal segment. Distal femur fractures in the elderly are frequently comminuted and very distally located. Interestingly, Hill et al. reported the presence of a coronal plane fracture (Hoffa fragment) in 44% of a cohort of patients over 65 years of age who sustained a supracondylar femur fracture, as a result of low energy trauma in most cases. The same authors reported a 66% incidence of Hoffa fractures in a younger cohort who sustained high energy trauma.

Distribution was also reported to be different, with elderly patients having lateral condyle coronal fractures more frequently compared with younger patients. As reported by the authors, these percentages are higher than previously reported and should be considered relevant as a missed Hoffa fracture could lead to early fracture displacement and fixation failure (8).

Unlike the young adult population, the associated vascular and neurological lesions are rare in these cases, being usually the fracture a consequence of low-energy trauma in elderly patients (6).

A subgroup of distal femoral fractures is represented by periprosthetic knee fractures. They have a prevalence of 0.5%-2.2% after primary total knee arthroplasty and 1.6-38% after revision total knee arthroplasty, increasing proportionally with age (particularly over 80 years) and with the increasing number of implanted prostheses (9-11, 12).

Management of these fractures is challenging and requires advanced skills in both trauma and prosthetic revision surgery.

Classifications

The classification most commonly used for distal femur fractures is the AO-OTA classification (33 - femur) which divides them in extra-articular fractures (type A), partial articular fractures (type B) and articular fractures (type C).

For periprosthetic fractures of the distal femur, the most commonly used classification is that of Rorabeck and Taylor (13), which takes into account the extent of fracture displacement and prosthesis stability (stable or mobilized), dividing fractures in 3 groups: nondisplaced fracture with stable prosthesis (type 1), fracture with displacement greater than 5 mm or angulation greater than 5° with stable prosthesis (type 2), and any supracondylar fracture with loosened prosthesis (type 3).

However, Rorabeck and Taylor do not consider in their classification the distance of fracture line from the prosthetic implant, that is an important factor for the choice of surgical technique (9).

Conversely, Backstein et al. have proposed a classification that takes into account the extension of distal fracture segment, stability of the prosthetic implant and bone quality, with the aim to distinguish between periprosthetic fractures that can be treated with osteosynthesis (extension of the distal fragment sufficient for the insertion of locking screws, stable prosthesis, good bone quality), from those that require a revision of the implant (distal fragment not sufficiently extended for locking screws insertion, loosened prosthesis) (14).

Treatment

The treatment of distal femur fractures in the elderly can be conservative or operative depending on fracture morphology and patients' characteristics. Simple, nondisplaced and extra-articular fractures can be successfully treated conservatively with plaster casts or braces. More complex fractures may be treated conservatively as well in patients with increased operative risks or with very low functional demands, especially non-ambulatory patients. However, the risks related to a prolonged immobilization and related complication must be weighed carefully with benefits of conservative treatment in these cases.

Nonetheless, operative treatment remains the main indication for most displaced and intra-articular fractures, with the aim to restore length, alignment and rotation, as well as restoring articular congruence of intra-articular fractures.

Various surgical options exist for treating distal femur fractures. Closed, minimally invasive or open reduction and internal fixation with a nail or a plate are the most commonly used techniques (5, 6, 15).

Some authors have proposed acute knee prosthetic replacement to treat distal femur fractures in elderly patients. However, evidence on indications and outcome is lacking at present (16).

Technical difficulties associated with fragility fractures osteosynthesis are related to structural and mechanical alterations that characterize the osteoporotic bone (Figure 1). The imbalance between resorption and formation of bone tissue leads to thinning and increased porosity of the cortical bone, as well as density reduction of the cancellous bone that reduces its mechanical resistance. The outcome of

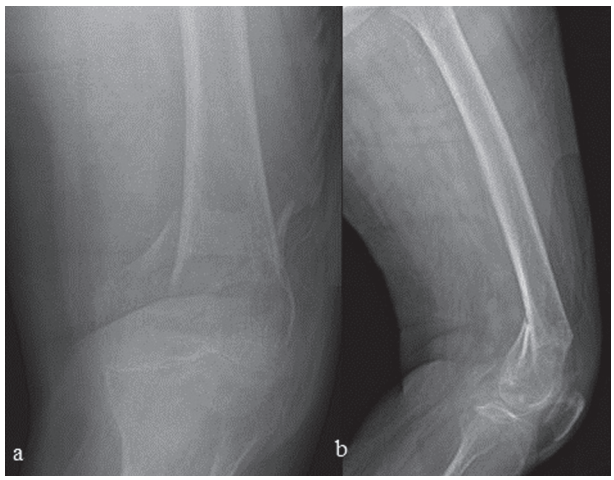

Figure 1. AP (a) and lateral (b) radiographs of a distal femur fragility fracture in a 90 years old woman with severe osteoporosis

surgical treatment depends on various factors that includes patient's characteristics, fracture type and the respect of soft tissues which allows preserving the biology of bone healing.

From a biomechanical point of view technical difficulties arise from metaphyseal comminution, presence of small articular fragments and the risk to create a too rigid or unstable construct that reduces screws grip in the osteoporotic bone with the risk of implant failure (17).

Another aspect to take into account is the presence of osteosynthesis devices or prosthetic implants (hip or knee prosthesis) that is not infrequent in distal femur fractures in elderly patients. Nonetheless, Loosen et al. reported the presence of preexisting implants in 58% of geriatric patients reporting a distal femur fracture (18). This eventuality complicates the surgical treatment, sometimes limiting therapeutic options. In these cases, for displaced fractures in patients in clinical conditions that allow surgical treatment, proper planning is essential to avoid the formation of stress raisers between the implants, which increases the risk of further fractures (19) (Figure 2).

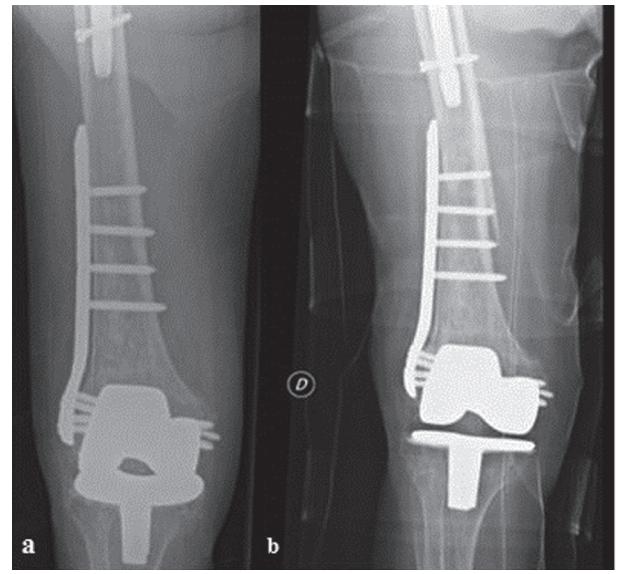

Figure 2. Stress riser related fracture a) 82 years-old woman treated with a too short locking plate for periprosthetic knee fracture and a previously implanted trochanteric nail, b) stress raiser related fracture between the implants as a consequence of low energy trauma

Intramedullary nail osteosynthesis

Intramedullary nail osteosynthesis is predominantly indicated for AO / OTA type A fractures, provided a sufficient extent of intact distal femur for housing distal locking screws. Indication might be extended to nondisplaced or minimally displaced intra-articular fractures associated to meta-diaphyseal fractures (AO / OTA type C1- C2) provided stable preliminary fixation of articular fragments with screws, which might not be easily reached in osteoporotic bone. The advantages of this technique reside in the possibility of closed reduction, minimally invasiveness that allows to respect fracture's biology and early weight bearing. Intramedullary nail osteosynthesis is not practicable in the presence of hip femoral stem and some types of knee prosthesis, as well as if the medullary canal is obstructed by osteosynthesis devices such as nails or screws.

Retrograde nail is nowadays the mostly used osteosynthesis device for treating distal femoral fractures. Compared to antegrade osteosynthesis, retrograde nails allow for an easier intraoperative control on small distal fragments and facilitates reduction if the correct entry point is respected. Moreover, modern retrograde nails have designs that offer multiple options for distal locking which determine its preferential use in clinical practice. The major concern in

distal femur fractures is distal anchorage. Data from biomechanical studies suggest that distal locking patterns have a significant influence on the mechanical stability of the bone-implant construct and on the mode of failure in fragility fractures. In osteoporotic bone, distal fixed angle locking constructs show a mean load to failure 38% greater compared with conventional locking technique. The presence of a condyle washer in the distal locking screw increases further the mean load to failure of 30% compared with conventional fixed angle locking technique when two anchoring distal screws are used (20).

Retrograde nails with a three-plane configuration of distal interlocking anchorage provides enhanced torsional and axial stability in osteoporotic bone, compared with other distal anchorage systems (21).

In the literature, concern has been issued regarding possible articular surface and posterior cruciate ligament's lesions due to retrograde nail insertion into the femoral groove. In elderly patients, limited iatrogenic damage to the articular surface may be tolerated considering the advantages resulting from limited surgical exposure required for nailing. On the other hand, despite the possible anatomical variability and the unavoidable entry point through the articular cartilage, a safe entry portal can be found anterior to the posterior cruciate ligament insertion and slightly medial to center of the intercondylar groove (22).

Retrograde nail osteosynthesis is also commonly used for treating periprosthetic knee fractures, as many modern prosthetic designs have an open femoral box that allows passing through of the nail (5, 15, 19, 23).

Antegrade nail osteosynthesis is currently used for treating distal femoral fractures in few cases. To allow its use, the fracture line must be located at least 5 cm proximal to the articular surface with most nail designs and at least 3 cm from the most proximal distal locking screw to allow adequate fixation. To maximize fixation stability, driving the nail tip as distally as possible is paramount, ideally just above the Blumensaat line (5, 15). Antegrade nails with multiplanar and angular stable interlocking options have the advantage of obtaining very high stability in the distal fragment, providing the possibility of nailing fractures close to the joint (24, 25).

Plate osteosynthesis

Plate osteosynthesis is indicated for all distal femur fractures types (AO / OTA type A, B and C). In literature, the possibility of using various devices for treating distal femoral fractures in elderly patients, such as conventional compression plates, fixed angle devices and the DCP system (Dinamic Condylar Screw, Synthes, CH) is reported. However, modern trends head towards the use of plates and screws with locking technology, especially in osteoporotic fractures due to the increased pull out resistance. The fixation technique with conventional plate relies on contact at the bone-plate interface to create stability, causing compression damage to the periosteum or the need for extensive periosteal stripping which negatively affects bone vascularization. Moreover, compression of an osteoporotic fracture might be difficult because of comminution and bone brittleness at the fracture site.

Latest generation of plate technology relies on the locking of screws on the plate holes to create a stable construct. The advantage of this system is that plates behave like an internal fixator, reducing periosteal damage and therefore optimizing the biological conditions for fracture healing. Modern plates allow the simultaneous use of angular stability screws (monoaxial or polyaxial depending on the implants used) and cortical screws, maximizing both systems advantages (5-6).

The main advantage of osteosynthesis with plate lies in the versatility that allows its use in almost any fracture configuration, especially in presence of hip prosthesis and some types of knee prosthesis, or in the presence of osteosynthesis devices that obstruct the femoral medullary canal, where nail fixation is not feasible (Figure 3).

Moreover, it can be performed through a minimally invasive approach (MIPO technique) for simple extra-articular fractures that can be reduced with external maneuvers (19).

Conversely, in displaced articular fractures, osteosynthesis is carried out with a standard lateral open approach since an accurate reduction of fragments is imperative. Alternatively, it is possible to use a minimally invasive approach for proximal fixation combined with an open distal epiphyseal approach.

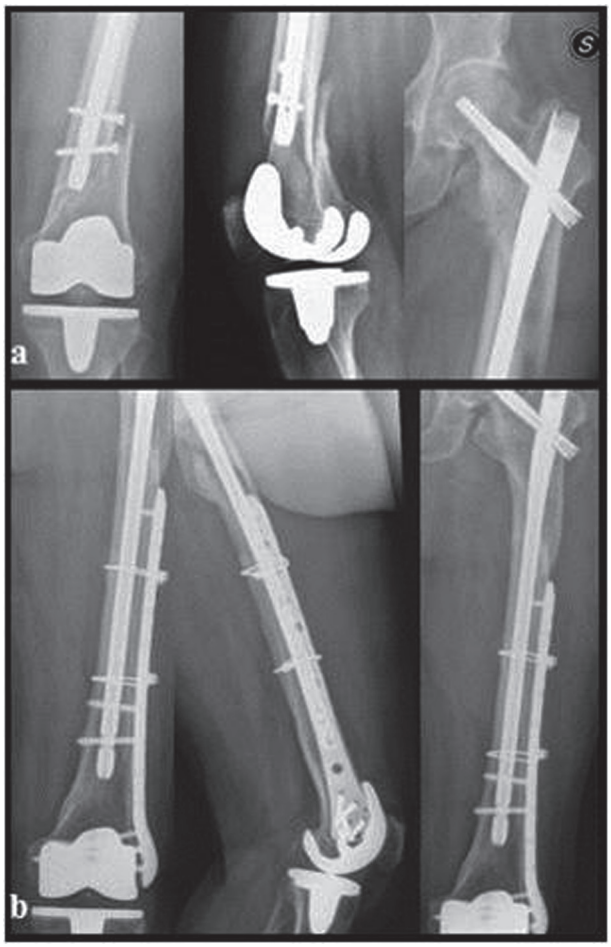

Figure 3. a) 79 years-old woman reporting a distal femur fragility fracture between a total knee arthroplasty and a previously implanted antegrade intramedullary nail b) radiographic control 2 years after open reduction and internal fixation with a locking plate stabilized with screws and cerclages (reprinted with permission from "Canton G. et al., Acta Biomed. 2017 Jun 7;88(2S):118-128. doi: 10.23750/abm.v88i2 -S.6522").

The main pitfall in locking plate osteosynthesis of distal femur fractures in osteoporotic bone is the risk of creating a too stiff construct that negatively influences the bone healing process. Multiple factors influence the mechanical strength or stiffness of a distal femoral locking plate construct. Bone quality and the fracture's pattern represent non-modifiable factors, but many others can be modulated under the surgeon's control. Some of these modifiable factors include quality of reduction, screws type, screws configuration, the length and position of the plate and the working length of the construct (26, 27).

Although without a solid evidence from literature and without definite indications for clinical practice, some authors suggest the use of combined cortical and locking screws for proximal fragment fixation, to avoid the risk of both fixation failure (all cortical screws) and of excessive stiffness leading to nonunion or implant breakage (all locking screws) (26-28).

Treatment of knee periprosthetic distal femur fractures

Periprosthetic distal femoral fractures are difficult to treat and require advanced skills in trauma and prosthetic surgery.

The goal of treatment is to get both fracture healing and a stable knee without residual malalignment to avoid prosthetic implant failure. Treatment choice depends on the stability of the femoral component, fracture type, patient clinical condition and eventual associated presence of other implants in the proximal femur (Figure 3).

As for other osteoporotic distal femur fractures, conservative treatment with plaster casts or braces is indicated for nondisplaced fractures or for patients not eligible for surgery.

Osteosynthesis can be performed with a stable prosthetic femoral component. Retrograde nail osteosynthesis is possible for most femoral prosthetic designs provided a femoral box wide enough for nail passing through. Moreover, an adequate bone stock and sufficient distal fragment extension for placing distal locking screws is paramount, with differences from non-periprosthetic fractures given by the femoral component encumbrance and possible bone loss from stress shielding. (29) Plate osteosynthesis can be used to treat very distal fractures or in the presence of proximal osteosynthesis / prosthetic components requiring for proximal fixation with monocortical screws and/or cerclages. In these cases, plate/stem or plate/nail overlapping is fundamental to avoid fractures between implants, with some authors suggesting a minimum overlap of 6 screw holes or twice the outer cortical diameter of the diaphyseal femur (30). Prosthetic implant revision is indicated in very distal and comminuted fractures in which an adequate fixation is not feasible, as

well as in presence of a loosened femoral component. In these cases, implant revision with a stemmed femoral component allows for stable fixation, early mobilization of the patient and early weight-bearing. If an inadequate metaphyseal bone-stock is present, the use of constrained prostheses with or without grafts may be necessary (9, 10, 31, 32).

Complications and outcomes

Main complications related to osteosynthesis of distal femur fractures reported in literature are nonunions, infections and osteosynthesis failure.

Non-union is the most common cause of re-operation in distal femur fractures (33). Many factors increase the risk of non-union, related to patient characteristics, fracture type and osteosynthesis method. Some factors are not modifiable by the surgeon, as smoking, diabetes, vascular diseases (causing a decrease in bone blood supply), advanced age, obesity, chronic use of NSAIDS or corticosteroids and tumors (which adversely affect patients' immune response). In a retrospective case-control study, Rodriguez et al. found a significant association between non-union and stainless-steel plates compared to titanium implants due to stiffness (34).

In literature, nonunion rates up to 35% are reported in studies performed at trauma centers mostly dealing with high-energy trauma (35). In fact, nonunions of distal femur fractures occur most frequently after high-energy trauma, in open fractures with huge comminution and in case of segmental bone loss (36). According to Ebraheim et al. non-unions occur more frequently when a metaphyseal comminution fracture pattern is present (37).

In a retrospective cohort study conducted by Moloney et al., the nonunion rate resulted to be higher in the 60-74 years old group than in the over 75 years old group (38). Nonetheless, according to Wenger et al., elderly patients treated with lateral locking plates suffer from nonunion less frequently compared to younger patients as a consequence of the lower trauma energy that is rarely related to severe soft tissues damage compromising fracture biology (35).

However, Moloney et al found in their study early complications after surgical treatment of distal femur fractures to be more frequent in the elderly population, with a 37,5% incidence of patients having at least one early post-operative complication such as respiratory/urinary tract infections or cardiac problems (38).

Kammerlander et al. found a significant reduction of mobility after distal femur fracture in geriatric population, with 23% of the population of the study (46 patient- mean age 80+/-9.3) being totally homebound, 26% unable to conduct any social activity and only 18% capable of social activities without assistance (7).

Interestingly, the importance of ensuring a mechanically stable construct allowing prompt rehabilitation with early motion in order to avoid bed-rest syndrome must be balanced with the higher failure rate of internal fixation in geriatric patients that are usually unable to adhere to partial weight-bearing protocols (39).

Athar et al. in a retrospective study of 78 patients (mean age 80-48% over 85) with distal femur fracture reported knee stiffness as the most common complication, although establishing if the stiffness was pre - existing or due to injury or treatment was impossible in most cases (2).

For distal femur fractures treated with total knee replacement, a 1-year mortality rate of 20%, a periprosthetic fracture risk of 2,4% and a 1-year revision rate of 3,4% are reported (16).

In a review of periprosthetic knee fractures internal fixation by Herrera et al., a nonunion rate of 9%, an implant failure rate of 4%, an infection rate of 3% and a reoperation rate of 13% are reported, without differences in outcomes between osteosynthesis with retrograde nail and locking plate (40).

Complications related with revision total knee arthroplasty for managing periprosthetic fractures do not differ from those faced during other revision knee procedures. However, treatment for periprosthetic fractures is frequently more challenging because of older age, comorbidities and often poor bone stock. These factors can raise the risk of perioperative complications. In the literature, fourteen percent of patients are reported to experience a medical complication postoperatively and 16% of patients are reported to suffer from a surgical complication requiring revision within the first 3 years postoperatively (41).

Conclusions

Distal femur fractures are severe injuries burdened by high rates of complications and mortality in the elderly. Allowing early mobilization is essential to prevent complications occurring in bedridden elderly patients. Early surgery can significantly reduce mortality and complications rates. Surgical treatment is frequently challenging as a consequence of osteoporotic bone characteristics and the frequent presence of osteosynthesis devices or hip/knee prosthesis which may limit available treatment options. Periprosthetic knee fractures represent a particularly challenging subtype of distal femur fractures, requiring advanced skills in both trauma and prosthetic surgery.

Ethical approval: "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed consent: "Informed consent was obtained from all individual participants included in the study."

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Review

Management of suprapatellar synovial plica, a common cause of anterior knee pain: a clinical review

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Summary. *Background and aim of the work:* Suprapatellar synovial plica is caused by a congenital thickening of the synovial membrane and is generally asymptomatic. In the literature, suprapatellar plicae are described as one of the causes of anterior knee pain however, their real role in determining symptoms is controversial. The aim of the current paper is to describe the anatomy, classifications, pathophysiology, symptoms and management of suprapatellar plica syndrome, as well as the differential diagnosis from other causes of anterior knee pain. *Method:* Via a search within the MEDLINE/PubMed database, a current review was conducted, and the results summarized. *Results:* Due to idiopathic, traumatic or inflammatory conditions, plicae can become pathological, causing anterior knee pain with possible knee clicking, swelling, giving way and locking after prolonged flexion of the knee. The diagnosis should be formulated based on an accurate medical history and clinical examination, followed by an appropriate imaging study. However, arthroscopy remains the "golden standard" for detecting all synovial plica. *Conclusions:* In patients with anterior knee pain, where doubt is present in the imaging investigation for intraarticular or periarticular lesions, pathological suprapatellar synovial plica must be suspected. The treatment should initially be conservative, but in cases where symptoms persist, patients should undergo arthroscopy to confirm diagnosis and to determine a suitable treatment. In the presence of pathological plica associated with cartilage damage of the femoral condyle or patella at the time of diagnostic arthroscopy, plicae excision leads to favourable results in a high number of cases. (www.actabiomedica.it)

Key words: suprapatellar synovial plica, anterior knee pain, plica management, knee arthroscopy, review.

Introduction

Knee synovial plicae are anatomically normal duplications of the synovial membrane and can be classified, based on their location around the knee, as suprapatellar, mediopatellar, lateropatellar or infrapatellar (ligamentum mucosum) (1). The most common is suprapatellar plica, which is reported in 20% to 90% of cases but has little clinical manifestation in comparison with the more frequently studied medial plica, which is reported in 20% to 60% of persons, and where knee symptoms are present in 2% to 9% of cases (2).

The role of suprapatellar synovial plica or *plica sinovialis suprapatellaris* in determining anterior knee pain is still controversial, because some asymptomatic suprapatellar synovial plica are a normal finding during arthroscopy or cadaveric studies. However, in some conditions, in both children and adults, they can become symptomatic due to idiopathic, traumatic, or inflammatory conditions of the synovial membrane (3). In a meta-analysis including 23 studies, 969 patients underwent surgical treatment for symptomatic synovial plicae; the average age was 25 years and no differences were present between male and female patients (2). Anterior knee pain is reported anteriorly around the patella and can be due to traumatic causes or repetitive micro traumas related to athletic movements, or can be a result of patellofemoral dysplasia,

idiopathic chondromalacia of the patella, osteochondritis or synovial folds (4). This pain can originate from various anatomical structures of the knee: subchondral bone, synovial tissue, retinacula, skin, muscle, nerves, tendons or adipose tissue.

The aim of the current paper is to describe the anatomy, classifications, pathophysiology, symptoms and management of suprapatellar plica syndrome, as well as the differential diagnosis from other causes of anterior knee pain.

Anatomy and Pathophysiology

Plicae are remnants synovial structures occurring due to the lack of septa reabsorption that divides the knee into three compartments, the superior, medial and lateral, during embryonic development (2). Suprapatellar synovial plicae is a fold generally located above the proximal pole of the patella. Its location morphology and size can vary, and it can completely or partially separate the suprapatellar bursa from the knee cavity.

In the literature, there are various suprapatellar plica classifications based on embryology, shape, size, location and extension across the suprapatellar bursa (5). The embryological classification reported by Zidorn divides the plicae into four types, based on their embryology and location with respect to the proximal pole of the patella, according to the following pattern.; Type I: a complete septum that separates the suprapatellar bursa and knee cavity, type II: a perforated septum with one or more small central holes, type III: a residuals septum with a remaining fold usually in a medial location; and type IV: a completely involute septum (6). Dandy identified 10 different types according to the septum extension through the suprapatellar bursa and found a complete septum in 4.2%, a perforated septum in 20.6%, a partial septum in 66.4%, and an absence of the septum in 8.8% of cases (7). On the other hand, Kim classified the fold, based on arthroscopic plicae anatomy, as an absent, vestigial, medial, lateral, arch, hole, or complete septum, with each type subdivided further according to size and extension (8). We prefer to use the simpler four type arthroscopic Sakakibara classification as follows. Type A: a complete septum or centrally perforated septum with a small hole and types B, C and D: an arcuate partial septum with medial, lateral and superior prevalence respectively (9).

The role of suprapatellar synovial plicae in determining anterior knee pain is controversial. Suprapatellar synovial plicae is a normal, very frequent finding during arthroscopy, but pathological symptomatic suprapatellar plicae is rarely reported. The complete septum and the centrally perforated septum with a small opening, corresponding to type A in the arthroscopic Sakakibara classification and representing 2% to 11% of all suprapatellar plicae (10), are closely associated with knee symptoms. There are two theories that explain the pathological patterns of plicae: the mechanical theory (11) and Pipkins's hydraulic theory (12).

The hypertrophic pathological plicae with mechanical impingement against the femoral condyle or the patella, is due to a complete septum (Fig. 1) or to a transformation of a non-pathological plicae via an inflammatory process after idiopathic, traumatic or repetitive micro traumatic events, or to some other conditions that affects the pliability of the knee synovial folds. Trauma in synovial plicae is reported in between 13% and 57% of cases by various authors (2, 3, 10), while symptomatic perforated septum is associated with the hydraulic theory, due to its one-way valvar mechanism with pain and swelling of the knee. (Fig. 2).

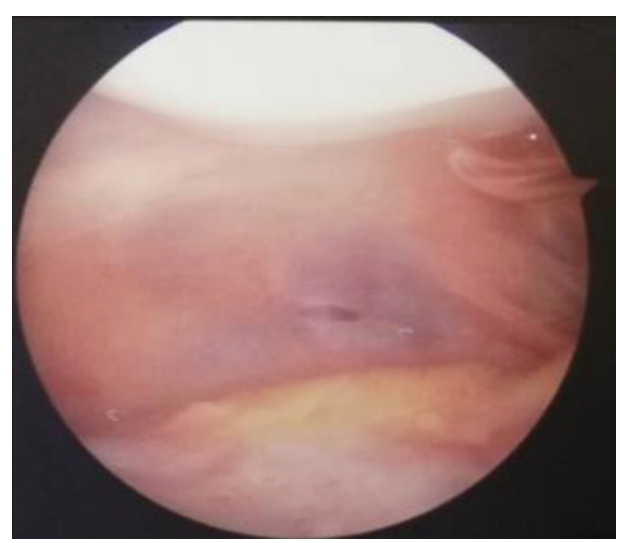

Figure 1. Suprapatellar synovial plica of the complete septum type situated above the superior patella pole

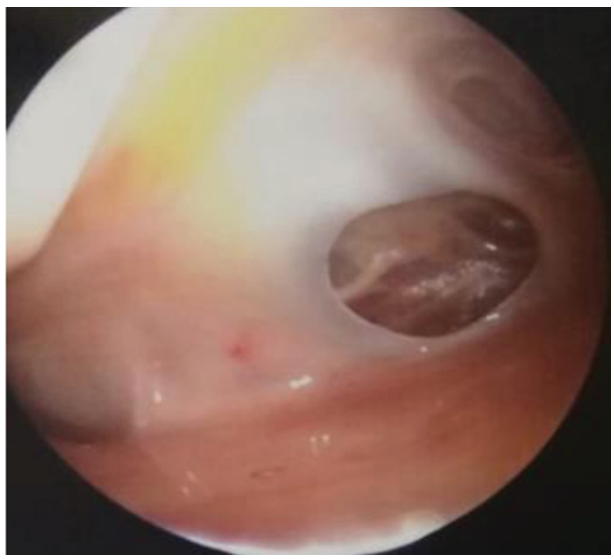

Figure 2. Perforated suprapatellar plicae with central small hole associated with the physiopathological hydraulic mechanism based on Pipkin's theory

Clinical Presentation and Differential Diagnosis

Anterior pain is the most common symptom of suprapatellar plica, located anterior to the patella above the joint line (4). Other symptoms include swelling, the knee giving way, the presence of a snapping sensation during the flexion movement, and the very important painful knee locking after prolonged knee flexion in a sitting position that we call "cinema sign". Symptoms must be distinguished from other causes of anterior knee pain.

The difficulties in diagnosing the anterior knee pain and determining the consequent treatment are linked to the non-specificity of the symptoms and signs. In 103 patients with synovial plica syndrome, in the absence of a meniscal tear or cartilage damage in the weight- bearing area, we found that suprapatellar and mediopatellar plicae were associated in 27% of cases. Pathological supra and/or mediopatellar plica were linked in 100% of cases with pain and in 86% of cases with knee locking after prolonged flexion of the knee "cinema sign" (personal communication at the Fourth International Conference of Orthopaedics, Biomechanics and Sports Rehabilitation, Assisi, December 1st-3rd, 2000).

Based on the aetiology, anterior knee pain can have several forms.

i. *Post-Traumatic*
   - Acute trauma: contusion, fracture of the patella or femur, dislocations, ruptures of the quadriceps or the patellar tendon.
   - Repetitive trauma: patellar tendonitis (jumper's knee), quadriceps tendonitis, prepatellar bursitis or apophysitis (Osgood-Schlatter disease or Sinding-Larsen-Johansson syndrome).
   - Late effects of trauma: post-traumatic chondromalacia, patellofemoral osteoarthritis, Hoffa's disease, reflex sympathetic dystrophy of the patella, bone dystrophy of the patella, acquired patella baja or acquired quadriceps fibrosis.

ii. *Patellofemoral Dysplasia*
   - Excessive lateral patellar pressure syndrome, chronic patellar subluxation, recurrent patellar luxation or, chronic patellar dislocation.

iii. *Idiopathic Patellar Chondromalacia.*

iv. *Osteochondritis Dissecans of the Patella and/or the Femoral Trochlea.*

v. *Synovial Plicae: Suprapatellar, Mediopatellar, Lateropatellar or Infrapatellar.*

Pathological plicae are not common but must be suspected in all cases of anterior knee pain, especially when pain is associated with knee locking after prolonged flexion. Dupont reported three cases of symptomatic suprapatellar plicae from among 12,000 patients (13).

Appropriate imaging studies include radiography, ultrasound, magnetic resonance imaging (MRI) and computerized tomography (CT) scanning (3, 14). Bilateral knee ultrasound is important for soft- tissue investigation and CT scanning in patellofemoral evaluation is mandatory in cases of dysplasia or high-riding patella. MRI is helpful for highlighting the presence of the synovial fold and for its measurement and the determination of its exact location (15). (Fig. 3) . Suprapatellar plica is visualized better on a sagittal MRI view, where it appears behind the patella, with a low-signal-bands type of aspect, sometimes delineated by high-signal joint fluid (16, 17). MRI is the examination of choice for investigating plicae, but arthroscopy remains the "golden standard" for detecting all synovial folds (16-18).

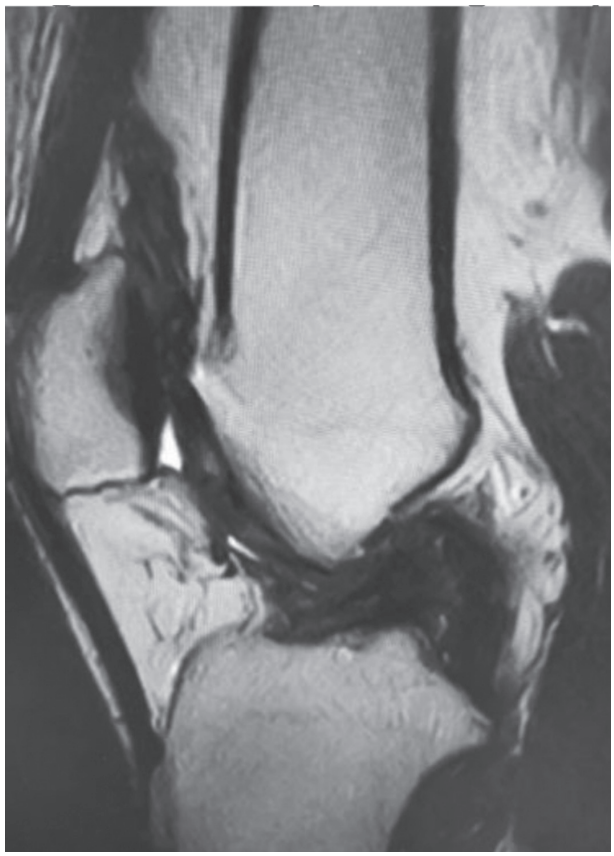

Figure 3. MRI of pathologic suprapatellar synovial plica

Treatment

The treatment of chronic anterior knee pain is initially conservative and includes resting, non-steroidal anti-inflammatory drug consumption, the use of braces and taping, proper athletic training with structured exercises and stretching for the hamstrings, gastrocnemius, and quadriceps, adequate footwear, weight loss, physiotherapy and in some cases, local articular injections (3, 19, 20).

This treatment usually aims at reduction of the pain and the state of inflammation, followed by a rehabilitation program in order to correct the biomechanics of the extensor apparatus. Amatuzzi reported a favourable outcome in 40% of cases after conservative treatment, in patients affected by synovial plica (20). The treatment of chronic anterior knee pain should be based on an accurate medical history and clinical examination, followed by an appropriate imaging investigation (3). In many cases, if conservative therapy fails after three to six months, surgical arthroscopic treatment is required. Pain is the major indication for knee arthroscopy (21-23).

The arthroscopic procedure is important for diagnosis and treatment (24) of all intraarticular lesions, and it can be done under general, spinal or local anaesthesia, but we must take into consideration the fact that plicectomy in local intraarticular anaesthesia is not helpful due to the fluid diffusion in suprapatellar bursa related to the high pressure pump. A tourniquet is not mandatory.

Pathological suprapatellar plica, diagnosed as the cause of knee symptoms, must be excised totally, using and antero-lateral, antero-medial or occasionally supero-lateral approach, leaving a thin synovial edge.

According to Patel, plicae showing thickening, fibrosis and abnormal size, are to be considered pathological (1) (Fig. 4). Strover describes the contact between the suprapatellar plica and the medial femoral condyle, with the plicae trapped between the quadriceps mechanism and the trochlea when the knee is flexed beyond 70°, using the arthroscopic supero-lateral view (25). The complete septum must be perforated with a smooth instrument before being excised. Arthroscopic aspects that guide us to perform plica excision are the shape, size, thickness and fibrosis of the plica. Another element maybe the presence of lesions on the articular cartilage of the non-weight-bearing

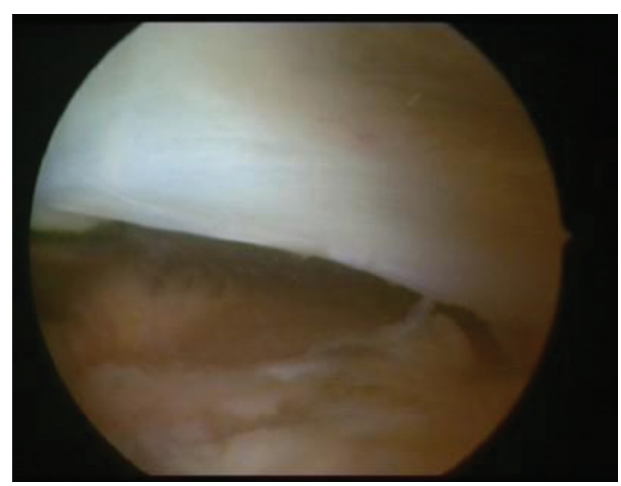

Figure 4. Pathological arcuate type of plica, associated with fibrosis, thickening of the border and abnormal size

femoral condyle area and on the patella, with limited synovitis due to plica impingement (26). If there is no other intraarticular lesion, plica of the complete septum type or the perforated septum type, and all synovial folds showing thickening fibrosis and alternate shape, must be removed. However, in the case of other associated intraarticular lesions, such as meniscus tears or cartilage lesions in the weight-bearing area, medical history and preoperative physical examination and investigation must help us to decide whether the plica must be removed or not. Plicae can be removed via basket, motorized shaver or radiofrequency methods. Accurate haemostasis must be performed to avoid postoperative hematoma (27). Patients underwent plica resection are able to resume normal daily activities, and complete recovery is achieved four to six weeks after arthroscopy (23, 25, 26).

The arthroscopic procedure for well-selected patients with plica syndrome results in a successful outcome (2, 3, 10, 17, 18). In fact , in a clinical trial, Johnson et al. reported a more than 80% success rate after arthroscopic plica resection in well-selected patients, and nearly 50% poor results in the control group; these patients were later returned for a definitive arthroscopic plicectomy (10). Kassim and Fulkerson reported a good outcome in 88% of cases at a four year follow-up after arthroscopic pathological plicae resection (28). In Schindler's meta-analysis, out of 969 patients at a 27-month follow-up, 90% reported a favourable outcome, with 10% failure (2). It was found that a good outcome was associated with younger age and well-localized pain with a short duration of symptom onset. On the other hand, a poor outcome was associated with incorrect diagnosis, the presence of severe chondromalacia, and extensor apparatus malalignment (2, 29, 30).

Conclusion

Anterior knee pain is one of the most frequent symptoms in knee disorders. The treatment is initially conservative. However, patients resistant to conservative therapy must undergo a surgical arthroscopic procedure. Preoperative diagnosis is very important and is closely related to the success of arthroscopic treatment. Diagnosis must be based on medical history, physical examination, and correct instrumental investigation (radiography, ultrasound and MRI). Synovial plicae is very common, but it is generally asymptomatic and of little clinical consequence. However, it must be suspected in every patient with anterior knee pain that is resistant to conservative treatment, especially when pain is associated with knee locking after prolonged flexion. In the presence of pathological plicae with cartilage damage of the femoral condyle or patella at the time of diagnostic arthroscopy, a plicectomy will be performed. In such cases, surgical treatment leads to good results in a high number of patients. Poor results are associated with severe patellar or trochlear chondromalacia or occur as a result of an inappropriate or inaccurate diagnosis. Open surgical treatment is rarely indicated**.**

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Review

From the central pivot to the peripheal knee injuries in the skier: a narrative review

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Summary. The improvement in the technology in the last 20 years has showed its main effect on the increase of the speed in the curves, thus leading to a rise of knee injuries. In fact, the most injured zone of the body was the knee (35,6 %) and the distal part of the lower body (11,5%), with ACL lesion as the most frequent diagnosis (49% of all the injuries to the knee) due to a trauma in valgus and external rotation in most of cases. The MCL is involved in the 15-20% of the cases while the LCL in only the 4,2% of the patients. Unique epidemiology and distinct mechanisms of injuries are peculiar for skier's knee while evaluation and treatment is similar to evaluation and treatment of knee injuries in other athletes. In this narrative review we aimed to highlight the current evidences in skiers' traumatology with special focus on the treatment nowadays proposed in the international literature and to the return to sport. (www.actabiomedica.it)

Key words: knee, ACL, MCL, LCL, MRI, ski

Introduction

There are few studies available evaluating alpine skiing competitions. In literature, the incidence of the lesions increased from the slalom (4,9 injuries / 1000 races) to the giant slalom (9,2 injuries / 1000 races) to the superG (11,0 injuries / 1000 races) to the downhill (17,2 injuries / 1000 races). With this ratio, all the specialties resulted as equally dangerous. The 45% of all the injuries in the World alpine skiing competition was detected during official competitions or in the world championship and only the 25,1% during regular training on the snow. The most injured zone of the body was the knee (35,6 %) and the distal part of the lower body (11,5%), with ACL lesion as the most frequent diagnosis (49% of all the injuries to the knee). In professional alpine skiing there is a higher overall risk of injuries in the male skiers compared to the females. Differently, in amateur skiing, the female skiers have twice higher risk of serious injuries to the knee compared to the males. The peripheral knee is less injured compared to the central pivot in the series reported in the literature. The MCL is involved in the 15-20% of the cases, while the LCL in only the 4,2% of the patients. Rare events in the skier are the lesions of the PCL and of the external posterior aspect of the knee, with a rate that is less than 1%. Also rare are knee dislocation (1,2 %) (1).

Injury mechanism

Usually, a trauma in valgus and external rotation. This is particularly valid in very skilled skiers. Among the beginners, external rotation in valgus and the "ghost foot lesion" are the most common injury mechanism. Falling from the skis after losing control, the skier takes a half-sitting position with the gravity center going posterior to the feet. The posterior aspect of the ski acts as a lever, pointing on the opposite side to the

foot ("ghost foot"), determining a forward directed acceleration and causing anterior translation of the tibia, eventually leading to ACL rupture. The "boot lesion" is another common injury mechanism to the ACL. After a jump, the skier touches the snow first with the posterior aspect of the ski. This determines an anterior passive force from the boots on the tibia, eventually causing ACL rupture (2). Both the mechanisms are based on translational forces without torsional forces, thus explaining the lower incidence of associated meniscal tears in the skiers than in non-skiers. Another hypothesis to explain the lower rate of associated meniscal tears is the reduced plantar overload that skiers have compared to other sports, even in case of a violent rotation of the knee (5). Regarding dislocation (both with low and high energy) that can occour during skiing, the biomechanics involves the forced hyperextension leading first to ACL rupture, then PCL rupture and an injury to medial or lateral structures according to the type of trauma (varus/valgus).

Diagnostic

First level imaging like X-rays and CT-scans are still considered to be highly reliable. Anyways, considering the frequent involvement of the capsule and the ligaments from the center pivot and the periphery, MRI has a fundamental role. For ACL rupture, MRI has a sensibility of 87%-94% and a specificity of 91%-94% (3). It has been shown that 83% of non-skiers had a bone edema on the lateral femoral condyle and the 78% on the postero-lateral border, thus suggesting valgus stress. In skiers instead the 81% has bone edema on the posterior aspect of the tibial plateau, proving thus that ACL rupture happens in hyperflexion while only the 40% had bone edema on the lateral femoral condyle, without valgus stress (1). For a proper follow-up is useful to highlight how the mean healing time of bone edema goes from 12 to 42 weeks, as demonstrated in literature. The remission is related to individual factors, such as the presence of osteoarthritis, the age and the type of bone edema (according to Vellet classification). Starting from this data, Boks et al. (4) recommend to have a follow-up with a MRI at 10 weeks, 6 and 12 months from the diagnosis.

Treatment

Surgical treatment is the gold standard in the ACL ruptures, especially in the young athlete: surgical timing is a crucial aspect. The reconstruction after acute injury can be performed in the professional athlete, to allow a quick return to the competitions. For the most people, the surgery has to be scheduled after an appropriate rehabilitation period, once reached 90° in flexion of the knee. The results in terms of ROM and stability have not shown difference between the patients treated <48 hours from the trauma and patients treated >3 weeks after the trauma. Different techniques are described in literature, from the riparation to the reconstruction, with or without augmentation. The reconstruction is performed with grafts: gracilis and semitendinous (Lindeman-Bousquet technique) or the central third of the patellar tendon with a small bone piece, taken from the patella (Kenneth-Jones technique) are the most common solutions and are well described in the literature. The results are excellent for both techniques and the return to sporting activity is in 6 months after the surgery. The Kenneth-Jones technique has shown a low re-rupture rate (5). Even if it has been widely demonstrate that a non-surgical treatment of an ACL rupture can lead to functional limitation and residual instability, a non-surgical approach can be used in inactive patients or also in amateur sportsmen. The rehabilitation protocol has to start immediately after the trauma and has the goal of reducing the local swelling, regain a full articular ROM and a good state of the quadriceps muscle. In I degree lesions (medial laxity in valgus stress <5 mm) and II degree (medial laxity in valgus stress 5-9 mm) of the MCL the treatment has to be conservative, with positive outcomes in the 98% of the patients and complete return to sporting activity. In III degree (almost always associated with ACL ruptures) the treatment has to be operative. It can be in one or two steps but the surgical indications helps to minimize the possibility of residual instability that , when chronic, is not easy to treat. When there are high-degree lesions in athletes and/or patients with heavy functional requests, we choose a surgical treatment to better restore the anatomy and to maintain a performance level equal to that previous to the lesion. In case of lesion of the superficial bands of the MCL,

it can be reinserted using titanium anchors, possibly in its anatomical site. When the deep bands of the MCL al ruptured, all the postero-medial compartment has to be re-tensioned (meniscofemoral ligament, femoro-tibial ligament and postero medial capsule) with reasorbable suture stitches. The same can be done for isolated lesions of the LCL, but in III degree lesions an involvement of all the postero-lateral structure and/or an ACL lesion is more common. Thus a more aggressive approach, surgery included, has to be immediately considered. The results depend on the severity of the lesion and on the athlete's functional requests. In fact, 82% of the athletes with a II degree lesion got back to the same performance level they had before the injury, while the 75% of the athletes with a III lesion got back to competitive levels, due to the residual instability (6). Knee dislocations are uncommon and are defined by complete disruption of the integrity of the tibiofemoral articulation (7). They are challenging injuries to manage and are associated with the risk of potentially devastating immediate and short-term complications, including popliteal artery injuries, common peroneal nerve injuries, acute compartment syndrome, and deep venous thrombosis, and controversy still exists regarding their optimal treatment (8).

Return to sport

Haida et al. (9) performed a retrospective epidemiologic study aimed to analyze the influence of the ACL rupture on French alpine skiers' postinjury performances from 1980 to 2013. The results show that skiers who suffered ACL tears were able to achieve podium success after injury, but it depended on their ages at the time of the ACL ruptures: the probability of obtaining better performance after this injury is higher if the rupture and subsequent recovery occur before the peak-performance age of 25 years. Moreover the authors show that the time necessary to achieve better performance after ACL rupture is on average 3.8 years for men and 3.1 years for women. Nevertheless, Ardern et al (10) showed that at 12 months after ACL surgery, 67% did not return to competitive sport, and only 33% tried to return to competition. Despite the severity of these injuries, a recent systematic review has demonstrated that some level of sport participation is possible after multiligament knee injuries (MLKIs) for more than half of patients, but returning to preinjury levels of sport after surgical treatment is low, at just 22% to 33%. To our knowledge, return to sport and postinjury performance after isolated MCL and LCL injuries in elite athletes have not been studied in alpine skiing. Sonney-Cottet et al (11) reported a case of a 25-year-old world-class downhill skier sustained bilateral knee dislocations after a fall at a speed of approximately 120 km/h during an international competition. Single-stage surgery was performed on each knee to manage all reconstructions and repairs. Ten months after the accident, he was able to return to skiing; 666 days after the accident, and after intensive training, he was asymptomatic and able to return to the Alpine Ski World Cup, referring to his knees as 'practically normal'.

Conclusion

Knee injuries in the skiers have a specific epidemiology and pattern of lesion. Anyway, nowadays there are not peculiar difference in the treatment compared to other sports. We think that a major commitment in the scientific community in the identification of the risk factors could provide essential knowledge to encode new prevention projects.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Leukocyte esterase strip test as a reliable intraoperative PJIs biomarker. Our experience

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Summary. *Backgroud and aim of work:* Prosthetic joint infection (PJI) is the most common cause of total knee replacement failure and the third most common cause of total hip replacement failure, accounting for 16.8% of all knee revisions and 14.8% of the hip revisions; nevertheless, the diagnosis of PJI is often a challenge for the orthopaedic surgeon. The aim of these study was to evaluate the reliability of the LE strip test for diagnosis of PJI. *Materials and Methods:* From December 2016 to January 2019, we enrolled 50 patients with suspected PJI; 32 females and 18 males, the average age at the time of the surgery was 76 years. Twenty-four patients underwent knee revision surgery and twenty-six hip revision surgery. In all patients during the surgery, the synovial fluid was aspirated and used for leukocyte esterase strip test. The result of the tests was compared to periprosthetic tissues culture, histological examination and sonication fluid culture for PJI. *Results:* Comparing the results obtained from the LE test with the results obtained from the other diagnostic methods, we found that the concordance between the results of the leukocyte-esterase test and those of the culture test with peri-prosthetic tissue or synovial fluid was shown to be 93%, between LE and histological examinations, the concordance was 93% and finally with the culture of the sonicated fluid the concordance was 86% of the cases. *Conclusions:* The results of our serie show a good intraoperative diagnostic accuracy of the LE test, especially in its ability to exclude the hypothesis of periprosthetic infection in case of a negative result. (www.actabiomedica.it)

Key words: leukocyte, esterase, periprosthetic, joint, infection

Introduction

Prosthetic revisions following infections in Orthopedics is an increasingly important and discussed topic (1, 2). Prosthetic joint infection (PJI) is the most common cause of total knee replacement failure and the third most common cause of total hip replacement failure, accounting for 16.8% of all knee revisions and 14.8% of the hip revisions. (3); nevertheless, the diagnosis of PJI is often a challenge for the orthopaedic surgeon.

Over the years various biomarkers have been identified and used to make a certain diagnosis of infection, the most used in the different periprosthetic infection diagnosis algorithms are the C-reactive protein (CRP) and the serum erythrocyte rate (ESR). Furthermore, new biomarkers are continuously being studied in order to achieve the right diagnosis and to choose the best surgical/medical approach, improving the decision-making process.

In the various international consensus meetings (ICM) on the PJI diagnostic criteria have been identified and divided into Major and Minor (4, 5); to make a diagnosis of infection there must be at least one major criterion or at least three minor criteria. Among the minor criteria, we find serological tests on blood and synovial fluid. Leukocyte esterase is also present among these biomarkers. CRP and ESR are the first biomarkers to be evaluated, but alone they are not sufficient: the CRP has a sensitivity of 88% and specifici-

ty of 74%, while the ESR has a sensitivity of 77% and a specificity of 70% (6). These two parameters cannot be used alone to monitor the persistence of the infection after a revision surgery (7). Today, other systems of investigation have been developed, such as α-defensin, which seems to show promising results.

In our Department, revision surgery for PJI is a common procedure. To approach PJIs, we apply a rigid protocol, known as the "Udine Strategy" (8) and since few years it has been implemented with the routine use of the Leukocyte Esterase (LE) strip test. The aim of our retrospective observational study is to show the reliability of LE in relation to ICM criteria and in comparison with other diagnostic tests and exams. Our results show that LE is a reliable method, especially for the intraoperative diagnosis of PJIs.

Materials and Methods

From December 2016 to January 2019, we enrolled 50 patients with suspected PJI; 32 females and 18 males, the average age at the time of the surgery was 76 years. Twenty-four patients underwent knee revision surgery and twenty-six hip revision surgery.

All patients underwent preoperative blood tests, ESR, CRP. During the operation, the synovial fluid was used for leukocyte esterase test and for microbiological culture examination; periprosthetic tissue samples were sent for intraoperative histological examination and for microbiological examination. The removed prosthetic components were also examined via microbiological culture after sonication.

For the LE test, we utilized "*Chemistrip 7 Urine Test Strips*" (Roche Diagnostics, Indianapolis, Indiana) – "Multistix" Siemens. According to literature, we considered the test as positive with 2+ and 3+ results, meanwhile, 1+ has been considered negative. All strips have been read at 1 and 2 minutes as recommended by the manufacturer.

A comparison was made between the LE test and the various diagnostic methods used (intraoperative histological examination with PMNs count, microbiological examination of culture and previous examination) both in a descriptive way, evaluating the percentage of cases in which the tests agreed both positively and negatively.

Results

Of the 50 cases examined, the LE test on synovial fluid was positive in 16, the intraoperative histological examination for leukocyte count was positive in 10 and in 3 was not performed, culture microbiological tests on periprosthetic tissue were positive in 12 and not performed in 1, the microbiological culture tests after sonication of the explanted prosthetic components were positive in 12, not performed in 1 and in 2 cases the results were positive only in one of the explanted components (1 head and 1 in the stem in 2 revisions of total hip prosthesis).

None of the LE tests was excluded due to blood contamination.

Comparing the results obtained from the LE test with the results obtained from the other diagnostic methods, we found that the concordance between the results of the leukocyte-esterase test and those of the culture test with peri-prosthetic tissue or synovial fluid was shown to be 93%, in 41 of the 44 cases examined the results were overlapping (Table 1). Performing the same operation between the leukocyte-esterase test and the intraoperative histological examinations, the concordance was 93%, being positive in 42 of 45 comparable patients (Table 2). Finally, we found that the LE test produced results which agree with the culture of the sonicated fluid in 86% of the cases, in 43 of 49 comparable cases (Table 3).

Using the criteria of the international consensus (4) the diagnosis of periprosthetic infection was made in 13 patients, 12 of these met the major criteria, presenting two or more positive cultures for the same micro-organism; 3 of these also presented with a fistula. One patient instead met three minor criteria, presenting positivity to the leukocyte-esterase test and to the synovial leukocyte count, to the percentage of PMNs neutrophils in synovial fluid and to PCR. Based on this, the accuracy of the leukocyte-esterase test was evaluated, showing a sensitivity of 100%, a specificity of 94%, a positive predictive value (PPV) of 84% and a negative predictive value (NPV) of 100 %. The same was also done for the other examined tests.

According to our data, the microbiological cultures reported a sensitivity of 80%, specificity of 100%, PPV of 100% and NPV of 92,86%, the intraoperative

Table 1. Comparison between cultural exam and LE test

	Cultures +	Cultures -	Total	
LE +	10	3	13	p = 0,023
LE -	0	31	31	
Total	10	34	44	

In green the number of patients in which both the exams (cultural exam, histological exam and cultures after sonication) and the LE test are negative, in red the number of patients in which both the exams and the LE test are positive.

Table 2. Comparison between intraoperative histological exam and LE test

	Histological +	Histological -	Total	
LE +	10	3	13	p = 0,03
LE -	0	32	32	
Total	10	35	45	

In green the number of patients in which both the exams (cultural exam, histological exam and cultures after sonication) and the LE test are negative, in red the number of patients in which both the exams and the LE test are positive.

Table 3. Comparison between sonication exam and LE test

	Sonication +	Sonication -	Total	
LE +	10	6	16	p = 0,025
LE -	2	33	35	
Total	12	39	51	

In green the number of patients in which both the exams (cultural exam, histological exam and cultures after sonication) and the LE test are negative, in red the number of patients in which both the exams and the LE test are positive.

histological examination a sensitivity of 80%, specificity of 100%, PPV of 100% and NPV of 92%, and the sonication of prosthetic components a sensitivity of 84%, specificity of 91%, PPV of 84% and NPV of 92%.

Discussion

Peri-prosthetic infections are a serious complication of joint replacement procedures, for this reason, it is necessary to make an early and accurate diagnosis, so to proceed, as soon as possible, with a specific multidisciplinary approach. An only-surgical or only-medical approach has been found to be ineffective; therefore, a structured cooperation of the orthopaedic surgeon and the infectivologist is crucial in the diagnosis and in the choice of the appropriate therapy.

We are trying to improve the promptness and accuracy of the diagnostic process, we are, therefore, studying and looking for new biomarkers, both in serum and in synovial fluid, usable in clinical practice. In the serum, besides CRP and ESR, IL6 and IL4 are currently being considered. In the synovial fluid, we find IL-6, IL-1b, IL-17, α-defensin and LE test (9,10). But while the various IL research tests are expensive, the LE test is very cheap because it uses common urine test strips.

In the study, the diagnostic accuracy of the LE test was evaluated by comparing it with the microbiological culture examination, the microbiological examination after sonication of the prosthetic components removed, and the intraoperative histological examination with PMNs count. While the first two tests require time for their execution, on average from 7 to 14 days, the intraoperative histological examination takes few minutes, and it can, therefore, influence the operator in the intraoperative surgical choice, facilitating the decision between prosthesis removal and reimplantation or the positioning of a cemented spacer.

The leukocyte-esterase has been extensively studied in the literature; this is an enzyme produced by PMNs during infection (11). For the test, we used the Chemstrip 7 urine test strip, simple and with very low costs. The sensitivity and specificity of the LE test for the diagnosis of PJI is 81% and 97% respectively, but this test also has the disadvantage of being illegible if contaminated with blood (12, 13).

In our centre, a rigid protocol is applied to deal with suspicion of PJI (8), the «Udine Strategy» which was implemented with the use of the LE test. After the introduction of this additional test, the results were good, and we found it to be a reliable intraoperative exam, which can help us in decision-making, complementing the information we receive from other intraoperative exams (14). The results of the LE test obtained show a significant concordance with culture tests (93%), with sonicates (84%) and with intraoperative histological examinations (93%).

These results show a good intraoperative diagnostic accuracy of the LE test, especially in its ability to exclude the hypothesis of periprosthetic infection

Table 4. Table of content of the results obtained with the different exams for each patient

	culture	sonication	Frozen section exam (>5° PMN/HRF=pos)	L.E. test
1	neg	neg	neg	neg
2	neg	neg	pos	pos
3	neg	neg	neg	neg
4	neg	neg	neg	neg
5	neg	neg	neg	neg
6	pos	pos	pos	pos
7	neg	neg	neg	neg
8	neg	neg	neg	pos
9	neg	neg	neg	neg
10	pos	pos	pos	pos
11	N.E.	N.E.	N.E.	neg
12	neg	neg	neg	neg
13	neg	neg	N.E.	neg
14	pos	pos	neg	pos
15	neg	neg	neg	neg
16	neg	neg	neg	neg
17	neg	neg	neg	neg
18	neg	neg	neg	neg
19	pos	pos	pos	pos
20	neg	neg	neg	neg
21	neg	neg	neg	neg
22	neg	neg	neg	neg
23	neg	neg	neg	neg
24	neg	neg	neg	neg
25	neg	neg	neg	neg
26	neg	neg	neg	neg
27	neg	pos	neg	neg
28	neg	neg	neg	neg
29	neg	neg	neg	neg
30	neg	neg	neg	neg
31	pos	pos	pos	pos
32	neg	neg	neg	neg
33	neg	neg	neg	neg
34	neg	neg	neg	neg
35	neg	neg	neg	neg
36	pos	pos	pos	pos
37	pos	pos	pos	pos
38	neg	neg	neg	pos
39	pos	pos	pos	pos
40	neg	neg	neg	neg
41	neg	neg	neg	neg
42	pos	pos	pos	pos
43	neg	neg	neg	neg
44	N.E.	N.E.	N.E.	pos
45	pos	pos	N.E.	N.E.
46	neg	neg	neg	neg
47	pos	pos	pos	pos
48	neg	N.E.	N.E.	pos
49	pos	pos	neg	neg
50	neg	neg	neg	pos

Notes: "neg" stands for negative, "pos" stands for positive, N.E. stands for not executed.

in case of a negative result. Again, a doubt may arise when synovial fluid is not obtainable or when it is contaminated with blood.

Many authors have studied α-defensin, as a biomarker for PJIs, which has been shown to have the highest diagnostic accuracy ratio (15). This biomarker is released by activated neutrophils (16), and its sensitivity is 100% and the specificity of 96%, as shown in a recent meta-analysis (12). An important disadvantage is the cost of this test, much higher than the LE test. We believe that, nowadays, the LE test still has a better price/performance ratio, it gives us the possibility to obtain reliable information in a short time and at a very limited cost.

A major limitation of our study is certainly the limited number of patients that have been enrolled, which could reflect a selected sub-population of patients and could, therefore, invalidate the investigation. In this regard, it would be necessary to increase the observation time so as to enrol a greater number of patients.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Comparison between conservative treatment and plate fixation for displaced middle third clavicle fracture: clinical outcomes and complications

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Summary. *Background:* Clavicle fractures are common injuries in adults, especially due to sport activities or road traffic accidents. Most lesions occur at the level of the middle-third presenting some degree of displacement often. Traditionally, non-surgical management was considered the first treatment option for the most clavicle fractures. Nowadays, various authors suggest early surgical fixation of displaced midshaft fractures. The aim of this study is to compare surgical versus non-surgical treatment and to evaluate the outcomes and the incidence of complications following to both treatment options. *Matherial and methods:* 87 patients with 2 displaced clavicle fractures fragments (AO 15.2A) were included in the retrospective study, evaluating the clinical and functional outcomes and the complication rate with a follow-up average of 48 months. *Results:* The risk of nonunion resulted lower in the surgically treated patients. The Constant Score after 1 year was slightly better after the plate fixation (94,36 vs 91,36), while the DASH score resulted better in the conservatively treated patients (3,86 vs 4,63). The delay or revision surgery rates were similar for both groups and most of the complications were associated with the conservative treatment. *Conclusions:* According to our results, the plate fixation does not lead to better clinical and functional outcomes, instead it reduces the risk of nonunion. We suggest to tailor the treatment patient-by-patient considering the functional demand, patient's comorbidity and nonunion risk factor. (www.actabiomedica.it)

Key words: clavicle fracture, plate fixation, figure of eight bandage, complication rate

Introduction

Clavicle fractures represents 2.5-10% of all fractures in adults (1-4). The risk is higher in young male patients aged less than 30 years and patients aged over 70. The main causes are a direct blow to the shoulder or a fall onto an outstretched hand (5), especially during sport activities or road traffic accidents. Middle third fracture represents 69% to 82 % of all clavicle fractures (4, 6, 7) and they often present some degree of displacement (8).

Nonsurgical treatment was considered the best option for most clavicle fractures with a good prognosis and a low incidence of nonunion cases (9-15).

Other authors suggest acute fixation of displaced midshaft fractures (16, 17), reporting more favorable outcomes over the past two decades and a higher patient's satisfaction.

Mandatory indications for surgical fixation of middle third clavicle fractures are open fractures, neurological or vascular compromise, skin tenting, widely displaced and comminuted fractures (18-20). Literature suggest that shortening of more than 2 cm, patients with multiple traumatic injuries, high-energy mechanism, younger athletic patients, and patients at risk of nonunion should address the surgeon's choice to surgical fixation (21-28). Displaced middle third clavicle fractures result in poor clinical outcomes, which in-

clude decreased strength and range of motion (ROM), ongoing pain, and patient dissatisfaction, especially in conservatively treated patients (17, 29). Malunion of middle third clavicle fractures impairs shoulder biomechanics (21, 23, 24, 30, 31) as well as, in some cases, causes neurovascular complications (30, 32).

The aim of our study is to compare the clinical outcomes of surgical and conservative treatment for middle third clavicle fractures in patients with a skeletal maturity, admitted between 2010 and 2017 in our department, evaluating the incidence of complications such as patient's pain, aesthetic skin scarring, patient satisfaction, painful skin scarring and shoulder ROM .

Materials and Methods

This is a retrospective study including patients with 2 displaced clavicle fractures fragments (AO 15.2A) treated at our department. Inclusion criteria: people older than 17 years old evaluated at the Emergency Room and treated with figure of eight bandage or with surgical fixation between January 2010 and November 2017.

Exclusion criteria: comminuted fractures, multiple fragment or pathologic fractures, corrective osteotomies, pediatric patients, intramedullary pin fixation.

Patients with a median follow-up time of 48 months were evaluated clinically, with the DASH questionnaire (33) and the Constant score (34). DASH questionnaire was composed by 30 questions rated 1 to 5 regarding the upper limb ROM. The responses were rated by a scale from 0 to 100, with 0 indicating no loss of ROM and 100 indicating complete loss of ROM. The Constant score, a 100-points scale composed of a number of individual parameter, defines the level of pain and the ability to perform patient's normal daily activities.

Lastly, we considered the complication rate in the non-operative sample and in the group who underwent plate fixation, considering the following: pain, anatomical defects, malunion, secondary fractures, neurovascular injuries, surgical wound dehiscence, and delayed union.

Statistical analysis was executed with an unpaired t-test in order to assess the significant differences between the 2 groups.

Results

We analyzed 50 patients who underwent plate fixation (Fig. 1) within 2 weeks from the injury (45

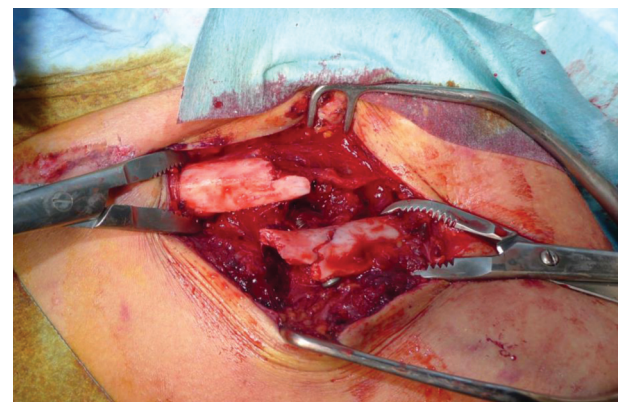

Figure 1A. Intraoperative picture of patients treated with ORIF technique

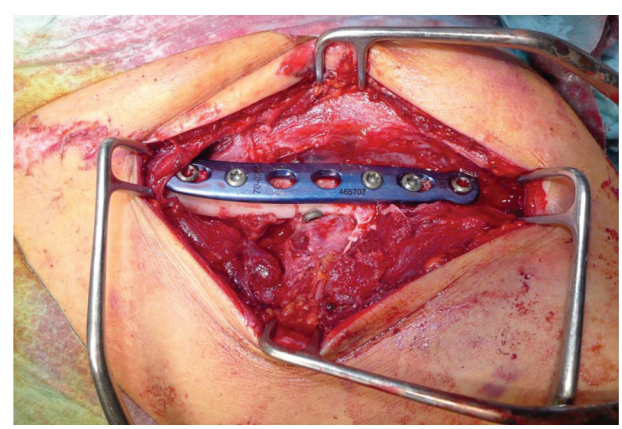

Figure 1B. Plate positioning

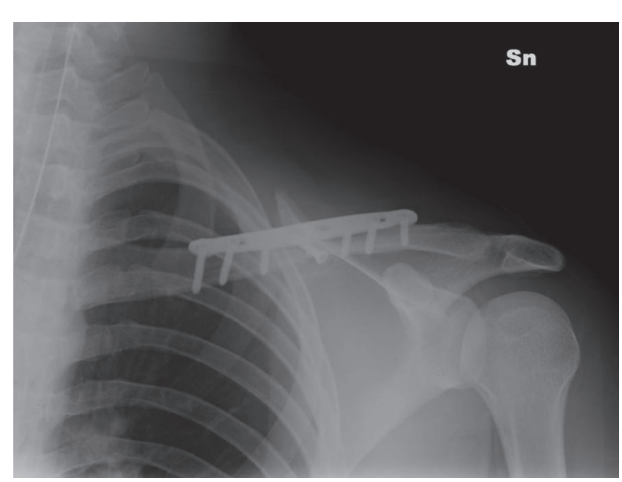

Figure 1C. Postoperative x-ray

males and 5 females) and 37 patients who underwent conservative treatment (9 females and 28 males) (Fig. 2). The mean age at the time of the injury, respectively for the first and second group, was 36.8 years old (ranging between 17 and 71 y/o) and 46.8 years old (ranging between 17 and 86 y/o).

In our cohort of patients, the mean Constant Score was 94.36 ± 9,85 for surgical fixation, while it was 91.56 ± 14,66 for figure of eight bandage treated patients. Considering the DASH score, the first group reported a mean score of 4.63 ± 5,21; whereas the second group reported a mean score of 3.86 ± 5,84. No correlation was found among the two groups despite our analysis and the p-value resulted of >0.5 in both DASH and Constant score.

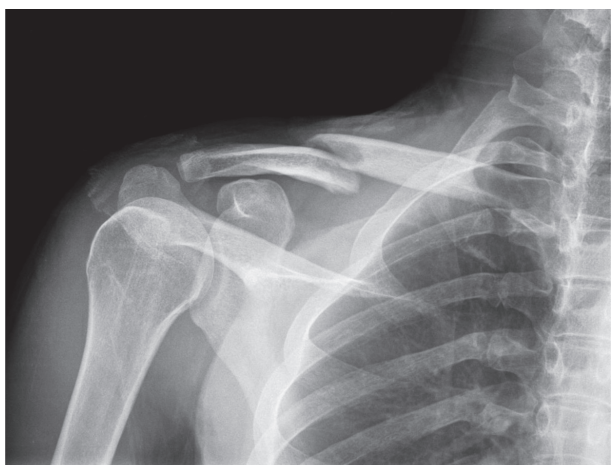

Figure 2A. Clavicle fracture treated conservatively (group 2)

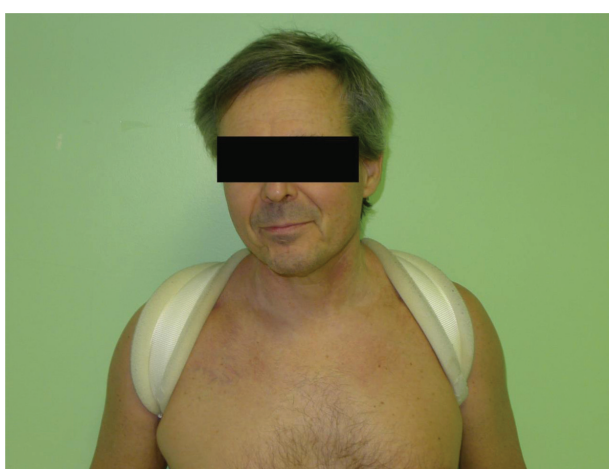

Figure 2B. Patient with figure of eight bendage

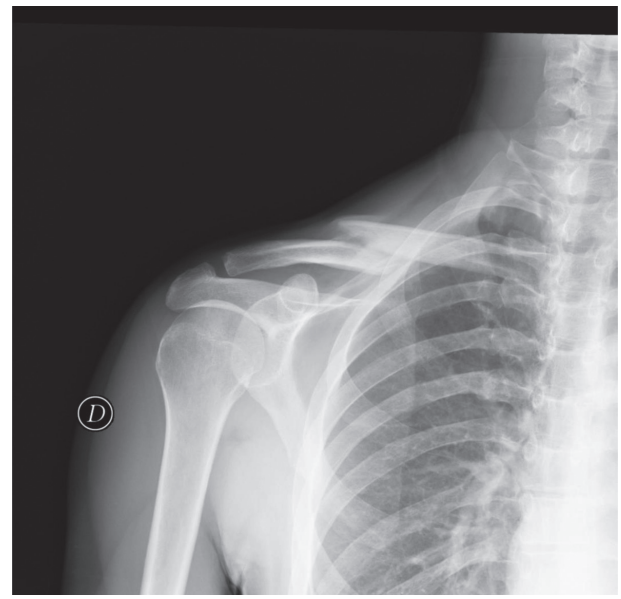

Figure 2C. X-ray control after conservative treatment.

We listed the number of potential disadvantages following to both treatment options to calculate the complication rate.

In particular, 15 out of the 38 patients who underwent conservative treatment (39,5%) were unsatisfied regarding the aesthetic appearance of the shoulder, however regarding the surgically treated patients, 6 out of 50 patients reported cosmetic dissatisfaction (12%)

In the first group, the 13,9th % of patients (5 out of 36) had to be treated surgically to solve the malunion.

In the second group, 10 out of the 50 patients (20%) had to undergo secondary surgery in order to remove the metallic implant.

Surgical wound dehiscence was present in 1 case among surgically treated patients, while hyperesthesia around the scar was reported by 7 patients.

Discussion

The aim of this study was analyzing whether patients with a displaced midshaft clavicular fracture are better managed with a plate fixation or a non-surgical treatment considering clinical results, functional outcomes and complication rate in patients treated at our department and comparing them to the literature.

In the last decades of 20th century, the conservative treatment was considered the gold standard because of the high rates of non union following both treatments reported in the past. In fact, according to Neer and Rowe in 1960, non union rate was less than 1% in patients conservatively treated, whereas the rates in surgically treated patients were higher (2, 14).

More recent studies show the changes of the indications, evaluating the reduction of nonunion cases in surgically treated inpatients. In the literature, multiple studies report lower rates of nonunion after plate fixation than conservative treatment (35), reporting a relatively higher incidence of non unions following to conservative treatment, causing a shift towards surgical treatment. Robinson et al. (36) performed secondary plate fixation in 81% of patients with non union fracture after 6 months. In Schemistch series for Canadian Orthopedic Trauma Society (COTS), all patients with a non union after 1 year follow-up period, underwent plate fixation (37). Melean et al. described secondary plate fixation in all 4 patients with a non union, but the timing was not listed (38). In the study by Woltz et al. (39), 5 patients were operated with a nonunion within a follow-up period of 1 year, underlining that the patients with a non union, who were about to undergo surgery, had a lower functional score than patients with a united fracture.

Our analysis confirms the results reported in more recent studies, showing less rates of nonunion in surgical group than in the conservative treatment group, all solved by secondary delayed surgery.

We reported that 10 patients in the operative group had to undergo secondary surgery to remove metallic implants, which is usually technically simpler, imposes less risk of complications, and provides shorter recovery time than other surgical procedures, such as secondary plate fixation with bone-grafting.

Considering the clinical scores in the previous studies, the Constant and DASH scores showed better results in the surgically treated group, than in the conservative group although the differences were only respectively 4.4 and 5.1 points, largely less than the 10 to 15 points, generally defined as the minimal difference for the clinical relevance (40-42). It remains controversial whether shortening of the clavicle after non-surgical treatment of a middle third fracture can affect shoulder ROM: in literature, there is no correlation between shortening and functional outcomes, even though the difference exceeds 2 cm (41).

Finally, the cosmetic issues were considered just in a few studies but, as well as we recorded in our cohort of patients, even in 2007 Canadian Orthopedic Trauma Society study, the surgically treated group of patients was more likely satisfied with the appearance of the shoulder (42) than the conservative group of patients.

In fact, although the surgical scar is largely visible over the shoulder, patients are more likely to consider the good clinical outcomes and rapid functional recovery, disregarding the cosmetic defect.

There were several limitations in our study: first we were not able to find statistically significant differences, probably because of the small sample size. Then, we did not evaluate the shortening of the clavicle. In conclusion, we noticed that the difference in the mean age between the two groups can affect the results, although very little. A larger number of patients and a longer follow-up timeframe is preferred in the future in order to assess a statistically significant difference between the 2 groups

Conclusions

Plate fixation of a displaced clavicular fracture does not result in improved clinical and functional outcome at 4 year follow-up period, but significantly reduces the risk of non union.

Therefore, we suggest an individualized patient-by-patient treatment, taking into consideration the functional demand, the general clinical diseases, the fracture characteristics and the nonunion risk factors such as large displacement.

We suggest surgical treatment as gold standard in young patients, who demand a fast recovery and a good upper limb ROM and should non union risk factors be <present, whereas conservative treatment can be considered a good option for elderly or less active patients, especially in case of risk factors that can contraindicate surgery.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Onlay versus Inlay humeral steam in Reverse Shoulder Arthroplasty (RSA): clinical and biomechanical study

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Summary. *Background and aim of the work:* Reverse shoulder arthroplasty (RSA) is becoming treatment of choice in glenohumeral arthropathies with massive lesion of the rotator cuff, due to a gradual extension of indications and new designs that provide better outcome. In this study we compared two different reverse shoulder prosthesis designs, defined as Inlay (or typical Grammont type) and a relatively new model defined as Onlay (that preserves tuberosity bone stock). We analyzed clinical, biomechanical and radiological outcomes, as well as complications of RSA in these two groups. *Methods:* We performed a prospective study on a population of 42 patients undergoing Reverse Shoulder Replacement by a single expert surgeon. We consider 21 patients (group A) who underwent to reverse shoulder replacement with a curved onlay steam with 145° inclination (Ascend Flex group, Wright medical, Memphis, TN, USA) and 21 patients who underwent to reverse shoulder replacement with a traditional Inlay Grammont steam (Modular Shoulder System SMR, Systema Multiplana Randelli; Lima-LTO, San Daniele del Friuli, Italy) between August 2010 and October 2018. We studied the following items: active range of motion (AROM), radiological parameters (lateralization shoulder angle LSA, Distalization Shoulder Angle DSA), functional scale (Constant-Murley Score), post-operative complications (infection, aseptical implant mobilitazion, residual pain, scapular notching, fractures, tuberosity reabsorbtion, dislocation, bleedings, nerve palsy, pulmonary embolus). *Results:* A significant improvement in ROM and functional score (Constant Shoulder Score) were observed in both groups. Group A (Onlay design 145°, medial tray) provides improvement in adduction, extension and external rotation compared to group B. No significant differences were found in abduction, external rotation and forward flexion. At 6 months follow-up, pain relief was detected in all patients. Although complications occur in a high percentage of patients in literature, no postoperative complications were observed in our cases series. *Conclusions:* Our results showed how RSA is a real solution to improve quality of life and to restore pain-free shoulder ROM in patients where cuff tear arthropathy occurs. Onlay design 145° may provides better active external rotation, extension, adduction: it is necessary to continue follow up and include more cases to prove these data. (www.actabiomedica.it)

Key words: reverse shoulder arthroplasty, inlay, onlay, cuff tear arthropathy, outcomes, ROM, Constant Murley Score, SMR, Aequalis Ascend Flex, scapular notching, LSA, DSA

Introduction

Background and aim of the work

Reverse shoulder arthroplasty (RSA) is becoming treatment of choice in glenohumeral arthropathies with massive lesion of the rotator cuff due to a gradual extension of indications and new designs that provide better outcome. In this study we compare two different reverse shoulder prosthesis designs, defined as Inlay (or typical Grammont type) and a relatively new model defined as Onlay (that preserves tuberos-

ity bone stock). We analyzed clinical, biomechanical and radiological outcomes, as well as complications of RSA in these two groups.

Massive cuff tears determinate gradual biomechanical joint alterations: forces and motion vectors are modified resulting in an antero-superior migration of the humeral head, and subsequent alteration of rotation fulcrum of the gleno-humeral joint: in motion, humeral head center showed a medial shift at the late phase of scapular plane full abduction and anterior shift at the internal rotation position during full axial rotation (1, 11, 21). Articular cartilage surface undergo to structural alterations and gradually a new joint is created between upper humeral head and acromial arch. Eccentric osteoarthrosis is the final progression of these alterations, characterized by severe pain (in particular night pain) and gradual restriction of active range of motion that could evolve to a condition defined "pseudoparalytic arm", in which patients can't move the affected arm independently (1, 11). Neer, in 1983, called this disorder "cuff tear arthropathy" (CTA) characterized by the association of gleno-humeral joint arthritis and a massive rotator cuff tear (1) (fig. 1).

The incidence of cuff tear arthropathy is about 2% in patients over 80 years of age (2). Conservative treatment should be tried in early cuff tear arthropathy (5, 6) but lesion dimensions and tendon's quality must be carefully evaluatued to give the best chance of success: pre-operative MRI evaluation is mandatory to analyze residual tendons integrity and grade of retraction and fatty infiltration (7, 12). In selected patients with absolute or relative contraindications to MRI, Multidetector Computed Tomography Arthrography (Arthro-MDCT) of the shoulder provides accurate diagnosis in identifying chondral, fibrocartilaginous, and intraarticular ligamentous lesions in patients who cannot be evaluated by MRI; Arthro-MDCT should be useful also after replacement surgery because it offers less artifacts generated by metal materials compared to post-operative MRI (10).

Computed Tomography (TC) study is indispensable for pre-operative planning (8). Currently we also have software to process TC images and elaborate a complete pre-operative planning: it is possible to choose different size of prosthesis components and perform a movement simulation in intra and extrarotation, abduction/adduction, elevation/forward flexion to find out any possible notching point (es. *Tornier Blue Print 3D Planning – Wright Engineered with IMASCAP Tecnology*) (9) (fig. 2).

The original indication for RSA was CTA, but the success of this implant has led to extend the indications. The procedure now is widely executed and RSA is indicated in patients with functioning deltoid muscle and with a unrepairable lesion of the rotator cuff, in the event of: rheumatoid arthritis, pseudoparalitic shoulder, avascular humeral head necrosis, severe proximal humeral fractures (Neer score 4) and fractures sequelae, correction of functional deformities, chronic shoulder instability, post infections arthrosis and revision after failure of previous shoulder arthroplasty or hemirthroplasty (11, 15-19, 24).

The Grammont prosthetic model is characterized by non-anatomical design (Fig. 3), that medializes the rotational center, refining the deltoid muscle lever arm and intrinsic stability of the implant in the absence of a functioning rotator cuff: this design increases deltoid efficiency and reduces mechanical torque at the gle-

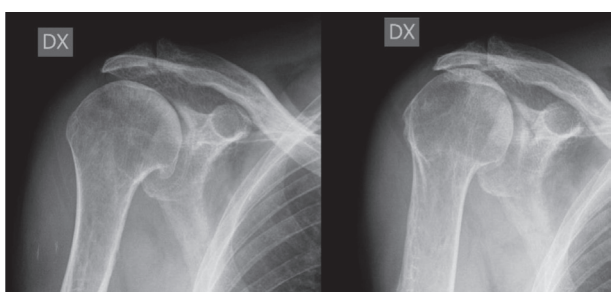


Figure 1. "Cuff tear arthropathy" (CTA) characterized by a massive rotator cuff tear that gradually leads to Eccentric Osteoarthrosis

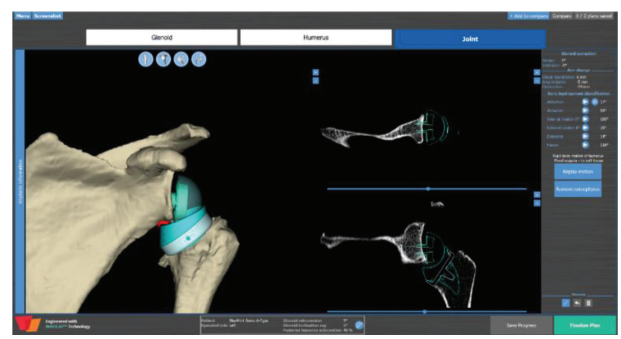


Figure 2. Pre-operative planning. The red spot on inferior scapular neck shows the Notching point

Figure 3. Reverse Shoulder Arthoplasty (P.Grammont, 1991, Delta III, DePuy)

noid component (decreasing glenoid loosening) (13, 14).

SMR system is a modular implant that consists of inlay humeral stem, reverse humeral body and reverse liner. Due to its modularity, different combinations are allowed: it is possible to adjust reverse liner dimension, diameter of glenosphere (30, 36, 44 mm), angle of retroversion, implant height and glenospheres eccentricity.

Lädermann et al. (25) showed effectively in Fig. 4 the design of traditional Inlay Grammont straight stem (inclination 155°) compared to Onlay curved stem (inclination 145°) and Onlay humeral tray. The red line passes through the center of the stem. Inlay steam causes humeral distalization but Onlay steam causes less humeral distalization and more lateralization (red arrow); moreover, the center of the Liner is medialized with the Inlay curved stem which results in more humeral lateralization (Fig. 4).

Onlay curved steam design also preserve tuberosity bone stock for eventually future prosthetic intervention, both proximally and distally: unlike traditional steams, curved design preserves greater tuberosity bone stock; short steam preserves distal canal bone stock (Fig 5).

Methods

We performed a prospective study on a population of 42 patients undergoing Reverse Shoulder Replacement. We considered 21 patients (group A) who underwent to reverse shoulder replacement with a curved onlay steam with 145° inclination (Ascend Flex group,

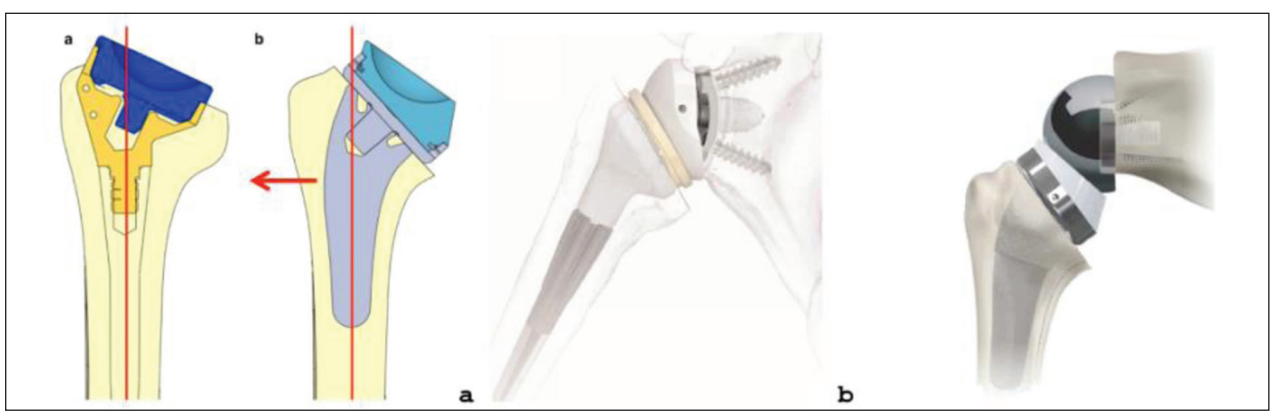


Figure 4. a. Inlay steam; b. Onlay curved steam

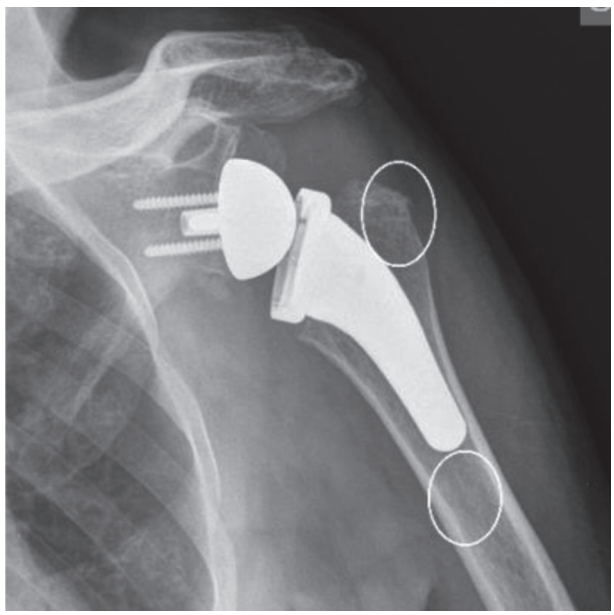


Figure 5. Onlay Aequalis Ascend Flex curved steam: bone stock preservation zones

Wright medical, Memphis, TN, USA) and 21 patients who underwent to reverse shoulder replacement with a traditional Inlay Grammont steam with 155° inclination (Modular Shoulder System SMR, Systema Multiplana Randelli; Lima-LTO, San Daniele del Friuli, Italy) between August 2010 and October 2018. For the 145° implant a 3,5 mm eccentric humeral tray was positioned in supero-lateral position, to minimize lateralization. All prosthesis were implanted by the same expert surgeon.

Exclusion criteria were: recent glenoid, scapular or humeral fractures, fractures sequelae, chronic or acute shoulder instability, previous shoulder surgery (except for arthroscopic rotator cuff repair), brachioradial plexus deficiency.

Inclusion criteria were: cuff tear arthropathy, eccentric arthrosis, eccentric or concentric arthrosis in patients who underwent to previous arthroscopic rotator cuff repair.

We included all the patients operated with Onlay implant that respected inclusion criteria and the last (temporary criterium) 21 patients operated with Inlay implant that respected inclusion criteria.

Mean age at surgical time in group A was 77 years±3.8, range [68-85] and in group B was 73±8,2, range [55-88]. Median age in group A was 77 years, in group B was 75 years.

Both Group A and group B included 6 male (29%) and 15 female (71%).

Operated arm is dominant arm in 12/21 cases (57%) in group A and in 14/21 cases (67%) in group B.

Both Group A and group B included 3 patient (14%) who previously underwent to an arthroscopic repair of rotator cuff in the same shoulder.

Mean follow up was 12 months.

Deltopectoral approach was performed in all patients, in beach-chair position.

In post-operative time, all shoulders were immobilized by simple brace for 2 weeks. Early passive mobilization was started in 1° post-operative day (except for forcing external rotation to allow subscapularis tendon repair). After 2 weeks patients started active assisted rehabilitation program.

Physical and radiographic assessments were performed pre-operative and during post-operative follow-up at 1, 3, 6 and 12 months after surgery. During physical evaluation, Active Range Of Motion (AROM) was evaluated in abduction-adduction, forward flexion-extension, external rotation (with elbow in anatomic position and 90° of flexion) and internal rotation; according to the International Society of Biomechanics, abduction, flexion were noted positively while adduction, extension, external rotation were noted negatively (20, 21). We found difficulties in standardized internal rotation measurements: most patients were unable to perform active internal rotation in supine position mantaining shoulder at 90° abduction, which is the way suggested to take goniometric parameters: according to the International Society of Biomechanics, internal rotation must be noticed in positive degrees values (20). In this study, to asses Internal rotation, Vertebral levels were converted to points using the method showed by Triplets et Al (22, 23) (fig. 6).

Pain relief was included in functional outcomes and measured using Constant-Murley Shoulder Score (Fig. 7).

We studied the following radiographic parameters: lateralization shoulder angle (LSA), Distalization Shoulder Angle (DSA), acromion-humeral distance (AHD), post-surgery humeral offset, scapular notching, tuberosity reabsorption. LSA and DSA were

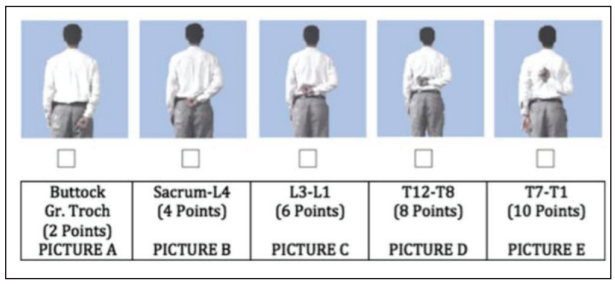
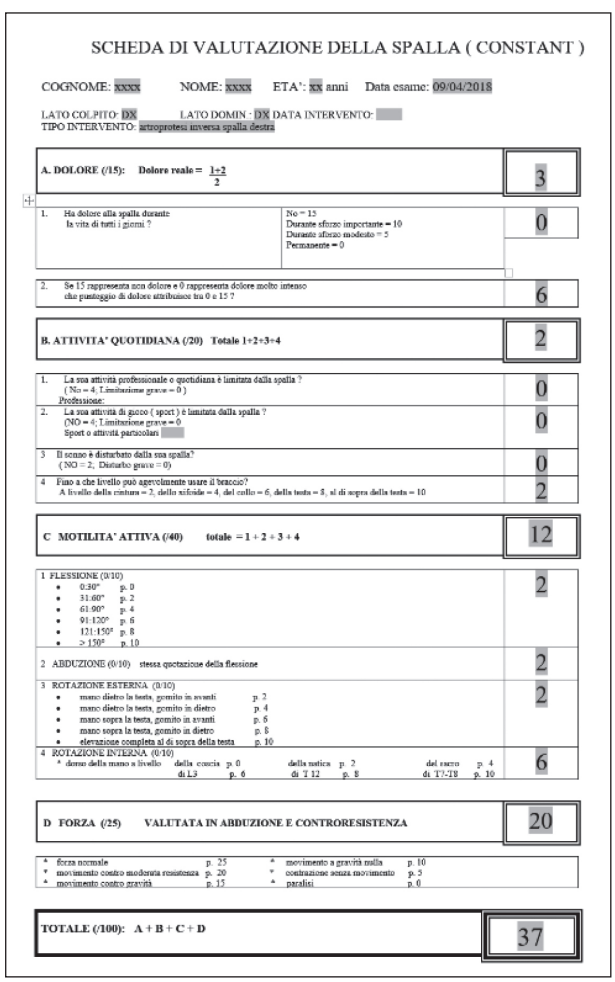


Figure 6. Active Internal Rotation: each image has a corresponding vertebral range. Vertebral levels are converted to points for analysis purposes (Triplets et al. (22)



SCHEDA DI VALUTAZIONE DELLA SPALLA (CONSTANT)

COGNOME: xxxx NOME: xxxx ETA': xx anni Data esame: 09/04/2018

LATO COLPITO: DX LATO DOMIN : DX DATA INTERVENTO:
TIPO INTERVENTO: artroprotesi inversa spalla destra

A. DOLORE (/15): Dolore reale = 1+2 / 2	3
1. Ha dolore alla spalla durante la vita di tutti i giorni ? — No = 15; Durante sforzo importante = 10; Durante sforzo moderato = 5; Permanente = 0	0
2. Se 15 rappresenta non dolore e 0 rappresenta dolore molto intenso che punteggio di dolore attribuisce tra 0 e 15 ?	6
B. ATTIVITA' QUOTIDIANA (/20) Totale 1+2+3+4	2
1. La sua attività professionale o quotidiana è limitata dalla spalla ? (No = 4; Limitazione grave = 0) Professione:	0
2. La sua attività di gioco (sport) è limitata dalla spalla ? (NO = 4; Limitazione grave = 0 Sport o attività particolari	0
3 Il sonno è disturbato dalla sua spalla? (NO = 2; Disturbo grave = 0)	0
4 Fino a che livello può agevolmente usare il braccio? A livello della cintura = 2, dello xifoide = 4, del collo = 6, della testa = 8, al di sopra della testa = 10	2
C MOTILITA' ATTIVA (/40) totale = 1 + 2 + 3 + 4	12
1 FLESSIONE (0/10) • 0-30° p. 0 • 31-60° p. 2 • 61-90° p. 4 • 91-120° p. 6 • 121-150° p. 8 • > 150° p. 10	2
2 ABDUZIONE (0/10) stessa quotazione della flessione	2
3 ROTAZIONE ESTERNA (0/10) • mano dietro la testa, gomito in avanti p. 2 • mano dietro la testa, gomito in dietro p. 4 • mano sopra la testa, gomito in avanti p. 6 • mano sopra la testa, gomito in dietro p. 8 • elevazione completa al di sopra della testa p. 10	2
4 ROTAZIONE INTERNA (0/10) * dorso della mano a livello dalla coscia p. 0 di L3 p. 6 della rotula p. 2 di T 12 p. 8 del sacro p. 4 di T7-T8 p. 10	6
D FORZA (/25) VALUTATA IN ABDUZIONE E CONTRORESISTENZA	20
* forza normale p. 25; ▼ movimento contro moderata resistenza p. 20; ▲ movimento contro gravità p. 15; * movimento a gravità nulla p. 10; ▼ contrazione senza movimento p. 5; ▲ paralisi p. 0	
TOTALE (/100): A + B + C + D	37

Figure 7. Constant-Murley Score

measured on standard anteroposterior radiographs by a single orthopaedist, blinded to surgical outcome, using the method illustrated by Boutsiadis et al. (28) (fig. 8, 9).

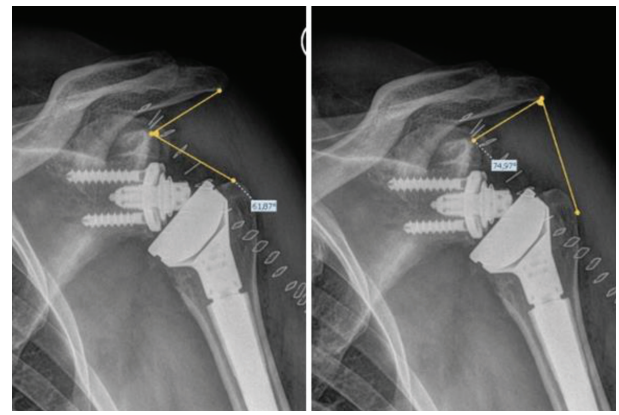


Figure 8. DSA and LSA angle in Inlay RSA (28)

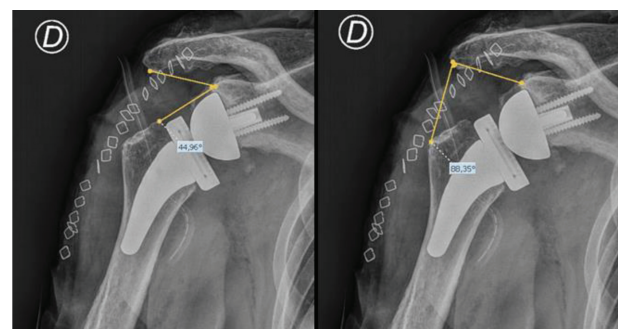


Figure 9. DSA and LSA angle in Onlay RSA (28)

All measurements were calculated using O3 Reporting Workstation (ORWS Insiel FVG Version 3.2.2) with an accuracy up to 0,01 mm. Scapular Notching and Tuberosity Reabsorption were evaluated in subsequent radiographs taken during post-operative follow up at 1, 3, 6 months and 1 year. Scapular Notching was evaluated on AP view in external and internal rotation and classified using Sirveaux Classification (26, 27).

We also reserched any complication during 1 year follow up: infection, aseptical implant mobilization, residual pain, scapular notching, fractures, tuberosity reabsorbtion, dislocation, bleedings, nerve palsy, pulmonary embolus.

Categorical variables were reported as frequencies and percentages. The Student's t test or the Mann-Whitney U test was used to compare continuous variables between the two groups. 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).

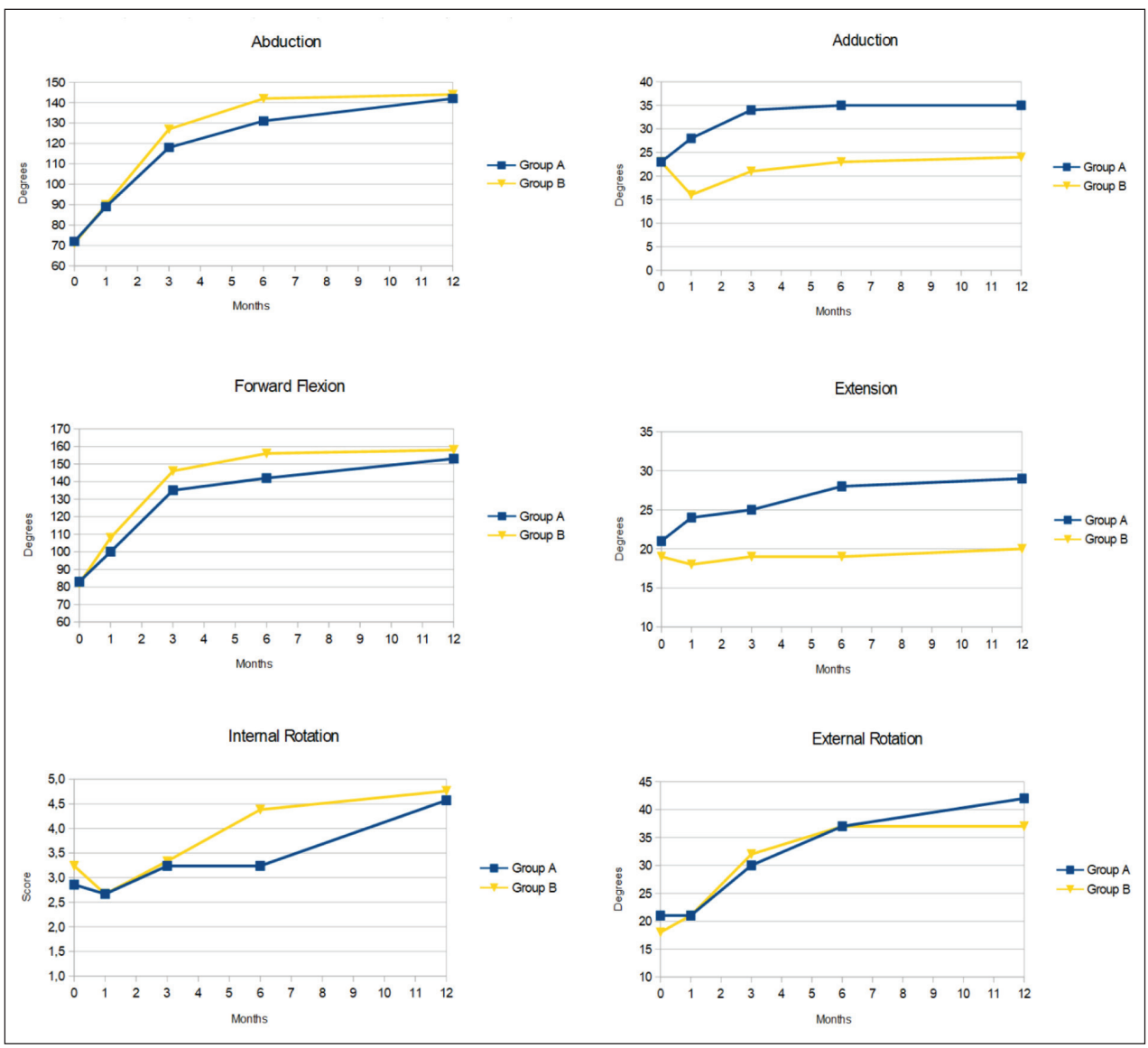
Results

Group A (Onlay steam) and B (Inlay steam) were omogeneus in median age at surgical time, gender composition, surgery related to dominant arm, previous arthroscopic surgery. Median age in group A was 77 years [68-85], in group B was 75 years [55-88]. Both groups included 29% male and 71% female. Operated arm is dominant arm in 57% of group A patients and in 67% of group B patients. Both Group A and group B included 3 patients (14%) who previously underwent to arthroscopic repair of rotator cuff in the same shoulder.

Maximum improvement in ROM was obtained at 6 months and it was maintained at 1 year after replacement in both groups.

At 1 year follow up, in group A (Onlay) mean AROM was: Abduction +142 °[100-170], Adduction -35° [20-45], Forward flexion +153°[120-180], Extension -29° [20-40], extrarotation -42°[30-60]; active internal rotation was 4,6 points (reported as mean score, as show in fig. 6). (Table 1)

Table 1. Postoperative improvement in active ROM: mean abduction/adduction, forward flexion/extension, extra/intrarotation. Degrees are noted as absolute values; internal rotation was reported as mean score



At 1 year follow up, in group B (Inlay) mean AROM was: Abduction +144°[100°-180°], Adduction -24° [15-40], Forward flexion +158°[120-180], Extension -20°[10-30], extrarotation -37°[20-40]; internal rotation was 4,8 (reported as mean score, as show in fig. 6) (Table 1).

Constant Shoulder Score was submitted to patients before surgery, at 1, 3, 6 and 12 months follow-up (Table 2). Group A (Onlay steam) and B (Inlay steam) were omogeneus in mean pre-operative Constant-Murley Score: Group A 39 points; Group B 41 points. There was no significant difference between two groups in Constant-Murley score at 1, 3, 6 and 12 months post-surgery, with a rapid restoration of pain-free AROM of the shoulder (Table 2).

At 3 months pain relief was detected in all patients except of 3 patients in Group A, who declared mild pain that was correlated to delayed phisioterapy: these 3 patients started active exercises 40 days post-surgery and gradually regained AROM in the following 3 months. At 6 months follow-up, pain relief was detected in all patients (parameter included in Constant-Murley Score). One patient declared that he was not satisfied for a distal humerus fracture with a complete lesion of radial nerve occurred 1 year after shoulder replacement but this fracture couldn't be considered as a implant complication (Fig. 10).

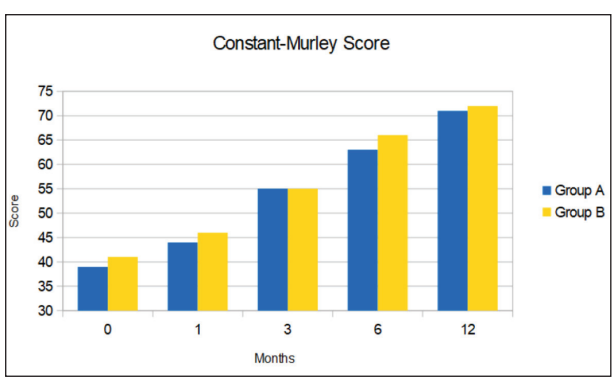
Regarding radiological findings, we discovered a linear correlation between LSA values and prosthesis offset (r=0.64, P<0.001): higher LSA values where found in more lateralized RSA (group A); we detected a Linear Correlation between DSA values and acromion-humeral distance AHD (r=0.62, P<0.001): higher DSA values where found in more distalizated RSA.

LSA and DSA angles showed negative linear correlation (r=-0,42, P<0.001): more distally the implant is placed, less lateralization is achieved. Mean LSA in group A was 92°±8.1, higher than in group B 81±5.4. Mean DSA in group A was 47°±6.9, lower than in group B 49±9.

We did not find significant positive correlation between LSA and Active External Rotation (R^2=0,15) and between DSA and Active Forward flexion (R^2=0,04) as demonstraded by Boutsiadis et Al (28).

Six months after RSA, inferior Scapular Notching was detected in 3 patients (24%) in group B. These patients developed a low grade of scapular notching (<5mm) which did not reach the lower screw (26, 27). The radiographic finding of inferior Scapular Notching did not correlates with worst functional outcomes in our series.

Table 2. The variation of Constant Shoulder Score showed no significant difference between group A and B



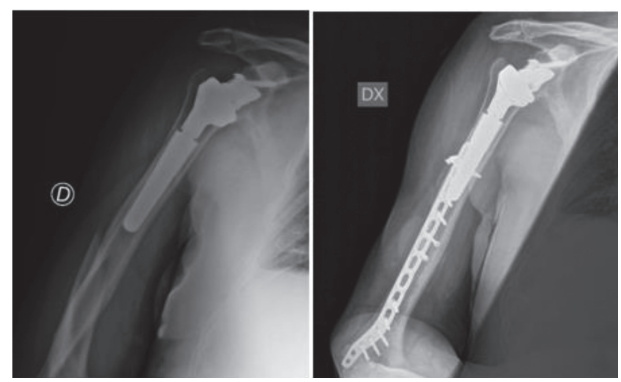


Figure 10. Distal humerus fracture with complete lesion of radial nerve occurred 1 year after shoulder replacement

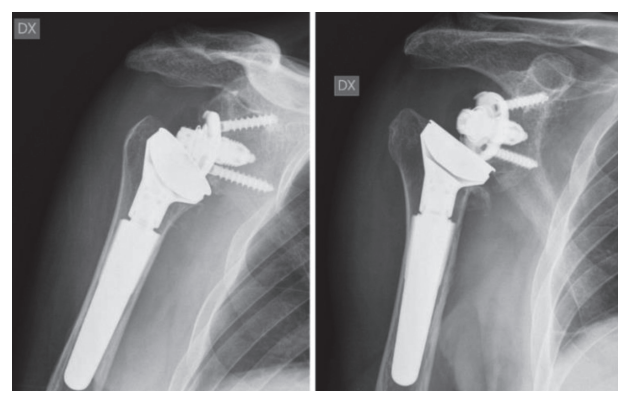


Figure 11. Scapular Notching, grade 1, at six month follow up

During follow up no other patients developed specific complications as: local and systemic infections, aseptical implant components mobilization, residual pain, fractures, tuberosity reabsorbtion, dislocation, bleedings, nerve palsy, pulmonary embolus.

Conclusions

Reverse shoulder arthroplasty (RSA) is an excellent surgical treatment to restore pain-free ROM, function and strength of the shoulder affected by massive irreparable rotator cuff tears and cuff tear arthropaty (3, 4, 32).

Group A (Onlay steam) and B (Inlay steam) were omogeneus in median age at surgical time, gender composition, surgery related to dominant arm, previous arthroscopic surgery. These parameters offered a good starting point for comparison. Outcomes of all RSA showed the capacity to restore pain-free ROM, function and strength, improving the quality of life. Constant-Murley functional score increased significantly after surgery in both groups.

In particular, compared to literature data, in our study, prosthesis reached a more satisfactory mean active range of motion.

It is now how loss of the external rotation is a serious problem, disclosed by several authors; also elevation recovery may not be enough to bring up this deficit; external rotation in these shoulders depends by teres minor muscle conditions: particularly in older patients, this muscle is often retracted, atrophied or fatty infiltrated (11, 33).

Group A (Onlay 145° inclination steam, with tray placed medially) showed at 1 year follow up an improvement in mean adduction (-35° vs -24°), extension (-29° vs -20°) and external rotation (-42° vs -37°) compared to Group B (Inlay traditional 155° inclination steam), while mean abduction (+142° vs +144°) and mean forward flexion (+153° vs +158°) slightly decrease. Internal rotation didn't show significant difference in the two groups. These data partially confirm L*ä*dermann et Al. study (25): they found that there was 9° decrease in abduction and 5° increase in adduction between an Inlay Grammont design and an Onlay 145° design with tray placed medially, which is the tray configuration that minimize total Onlay humerus lateralization; they also described a dramatic improvement in extension and external rotation but in their study forward flexion remains unchanged (25).

Regarding radiological findings, we discovered a linear correlation between LSA values and prosthesis offset ($r=0.64$, $P<0.001$): higher LSA values where found in more lateralized RSA (group A); we detected a Linear Correlation between DSA values and acromion-humeral distance AHD ($r=0.62$, $P<0.001$): higher DSA values where found in more distalizated RSA.

LSA angle is a reproducible measurement to estimate implant lateralization, DSA is a reproducible measurement to estimate implant distalization. LSA and DSA angles showed negative linear correlation ($r=-0,42$, $P<0.001$): more distally the implant is placed, less lateralization is achieved. Mean LSA in group A was 92°±8.1, higher than in group B 81±5.4. Mean DSA in group A was 47°±6.9, lower than in group B 49±9. So, Inlay steam causes humeral distalization but Onlay steam causes less humeral distalization and more lateralization.

These values express how, biomechanically, Onlay prosthesis with its short stem, with curved metafisary grip, is able to lateralize the humerus more than Grammont traditional steam. This evidence is found in our study, on implants where the tray was placed medially (supero-lateral position): therefore it is evident that the design of the model itself gives greater lateralization in comparison with the traditional stem. L*ä*dermann et al. (25) stated that eccentric tray position had a little influence with humeral offset only increasing by 1.8 mm when moving from "supero-lateral position" to "infero-medial position" and concluded that humeral offset is more affected by curved onlay steam design that by inclination (155° -145°) or tray position.

Inlay RSA provided in our study higher DSA values, that correlated with higer distalization (higer acromion-humeral distance): this arm lengthening didn't affect functional outcome.

In comparison to Boutsiadis et Al. study, we did not find significant positive correlation between LSA and Active External Rotation ($R^2=0,15$) and between DSA and Active Forward flexion ($R^2=0,04$) (28). In their study LSA and DSA measurements were correlated with post-operative AROM outcomes: LSA

angles between 75° and 95° were correlated to better active external rotation and DSA angles between 40° and 65° resulted in better active forward flexion.

Onlay curved steam design also preserve tuberosity bone stock for eventually future prosthetic intervention, both proximally and distally; unlike traditional steams, curved design preserves greater tuberosity bone stock and short steam preserves distal canal bone stock: these features could be useful to plan RSA in patients younger than 65 years old, who are more likely to undergo to implants revisions (24, 29-31).

Although in literature intraoperative and perioperative complications occur in a high percentage of patients and long term outcomes are difficult to predict, during 1 year follow up none of the patients included in study developed specific complications as: local and systemic infections, aseptical implant components mobilization, residual pain, fractures, tuberosity reabsorbtion, dislocation, bleedings, nerve palsy, pulmonary embolus. A heparin prophylaxis was gave to all patients for 35 post-operative days.

In our study 3 patients in group B (14%) showed a low grade (grade 1 of the Sirveaux classification) of scapular notching six months after surgery but radiographic finding of inferior Scapular Notching did not correlates with worst functional outcomes in our series (26, 27).

Scapular notching has been attributed to a mechanical impingement of the humeral liner against the scapular neck when the arm is fully adducted. It can developed an osteolytic process as a result of wear debris of the polyethylene liner; the radiographic incidence increase with time and concerns between 49% and 70% of patients. It is now unknow if Scapular Notching really affects the function or lead to prosthesis mobilization (3, 11, 26, 27).

We concluded that our experience with SMR and Aequalis Ascend Flex RSA shows two safe and effective surgical options to resolve pain and restore the capacity to perform daily activities.

The major limitation of our analysis was represented by the small population evaluated in the present study (42 RSA). An another important limitation was represented by the short follow-up in the context of arthroplasty surgery. In particular Group A included more recents implants and we need to contiunue follow-up to obtain more data, above all about complications, in order to be able to extend safely surgical indications to younger selected patients in the future.

In addition, all patients in this series were operated by the same arthroplasty shoulder surgeon (selection bias). We initially found some difficulty in comparing our data with those provided in literature by similar studies because we had found different and not always specified measurement methods for Active Range of Motion. To facilitate bigger metaanalysis, we suggest to follow the ISB recommendation on definitions of joint coordinate systems (20) and Green and Triplet measure for internal rotation (22, 23).

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

The role of vascularized flaps in the treatment of proximal pole avascular necrosis in scaphoid non-unions

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Summary. *Objectives:* The purpose of this study is to evaluate the clinical and radiological outcomes of scaphoid non unions surgically treated with bone graft versus medial condyle corticoperiosteal free flaps. *Materials and Methods:* 32 patients were divided in 2 groups. Group A (17 patients 12male, 5 females, mean age 35 years old) treated with bone grafts; Group B (15patients 11 male, 4 females, mean age 33 years old) treated with medial condyle cortico periosteal free flap. A radiological follow up was performed about every 30 days after surgery until the complete healing and at 12-month follow-up. The clinical follow up was performed at 6 and 12 months from surgery. Functional assessment was provided by Mayo wrist score and Visual Analogic Scale (VAS). *Results:* The average length of follow up was 12.52 months ± 1.36. In group A 60% of patients healed in 4.4 ± 1months with a reduction of 28.4% of healing times in group B ($p<0.05$).In Group B all nonunion sites healed primarily at an average time period of 3.2 ± 1 months. Statistical analysis showed a significant difference ($p<0.001$) about the preoperative and the postoperative VAS and Mayo Wrist Score evaluation in both groups at 6 and 12-month follow-up, moreover we recorded a statistical difference between groups at the 6-month and 12-month follow-up ($p<0.05$). *Conclusion:* The present study showed that the free flaps showed better clinical and radiographic results for the surgical treatment of scaphoid nonunions. In fact, despite the good results of the bone graft, the flaps seems to be preferable in the treatment of these nonunions. (www.actabiomedica.it)

Key words: scaphoid nonunion, corticoperiosteal flap, microsurgery

Introduction

Acute scaphoid fractures account for 2% to 3% of all fractures, approximately 10% of all hand fractures and between 60% and 80% of all carpal fractures (1). The incidence of scaphoid fractures quoted in the literature is inconsistent with a range from 1.5to 29 fractures per 100,000 persons per year (1-4).

Scaphoid fractures usually occur after a fall on to the outstretched hand or during sports (1, 2) but is also documented that a low-energy fall from standing height occurred more frequently in females, with males more likely to sustain their fracture afterahigh-energy injury such as sports or a motor vehicle collision (2).

The natural history of scaphoid fracture nonunion is unknown as the majority of patients represent due to new or on-going symptoms. The quoted rate of nonunion is variable due to a lack of agreement regarding the criteria for union and the imaging modality that should be used. Nonunion is said to occur in approximately 10% of all scaphoid fractures, but the rate is much lower for nondisplaced fractures and approaches zero when a nondisplaced fracture is adequately treated and protected (5, 6). Displaced fractures have a 50% nonunion rate, with an increased rate also seen with

proximal pole fractures (7). Other proposed risk factors for nonunion of scaphoid waist fractures include delayed diagnosis or treatment (8, 9).

Scaphoid nonunion with avascular necrosis of the proximal fragment represents a challenge. Surgical options include nonunion repair using both bone grafts or free vascularized cortico periosteal grafts including the medial femoral condyle flap (10, 11). The rationale of this technique was based on the evidences suggesting that superior healing rates are achieved with medial femoral condyle free flaps over pedicled bone grafts (10-12).

The aim of this retrospective study is to evaluate the clinical and radiological outcomes of proximal pole avascular necrosis in scaphoid nonunions surgically treated with bone graft versus medial condyle corticoperiosteal free flaps.

Materials and Methods

From April 2013 to April 2015 37 patients with scaphoid non union were enrolled in the present study. All the patients gave the informed consent prior being included into the study.

The study was authorized by the local ethical committee and was performed in accordance with the Ethical standards of the 1975 Declaration of Helsinki as revised in 2000.

From the original 37 patients 32 met the inclusion criteria and were available for the follow up. These 32 patients were divided in 2 groups. Group A (17 patients 12 male, 5 females, mean age 35 years old) treated with bone grafts; Group B (15 patients 11 male, 4 females, mean age 33 years old) treated with medial condyle cortico periosteal free flap according to Bishop (13).

Inclusion criteria: age >18 years old, bone gap >3 mm, time from injury >6 months,no evidence of fracture consolidation on three consecutive radiographs in two projections more than 6 months after the fracture, no infections, initial conservative treatment of scaphoid fracture,no previous surgery on the index wrist or contralateral wrist, small defect, high grade avascular necrosis of the proximal pole of the scaphoid.

Follow-up

A radiological follow up was performed about every 30 days after surgery until the complete healing and at 12-month follow-up. The clinical follow up was performed at 6 and 12 months from surgery. Functional assessment was provided by Mayo wrist scorewith 0 reflecting majordisability and 100 reflecting complete recovery of the wrist. Pain was quantified using the Visual Analogic Scale (VAS), with 0 indicating absence of pain and 10 indicating maximum pain. Focusing on the donor site, postoperative X-rays were taken until bone healing. The pain using the Visual Analogic Scale (VAS) and the range of motion (ROM) were evaluated.

Postoperative Rehabilitation

Immediately after surgery, all patients were encouraged to elevate the hand and begin early finger motion. A short arm plaster splinting was maintained for 5 weeks. At that 2 weeks follow-up the dressings and sutures were removed; at the 5 weeks follow-up the therapy was started under the supervision of a certified physiotherapist. During weeks 2 through 6, an anti-edema protocol was started along with tendon gliding and range of motion exercises.

Statistical Analysis

One-way Analysis of Variance (ANOVA) with a post hoc Tukey test was used to compare Mayo Wrist score, VAS scores between groups. In the donor site the ROM pre op and the ROM post op data were compared using the Student *t-test*. Statistical significance was set at p-value of 0.05. All tests were performed using SPSS (version 20, IBM, UK).

Results

The average length of follow up was 12.52 months ± 1.36.

In group A 60% of patients healed in 4.4 ± 1 months with a reduction of 28.4% of healing times

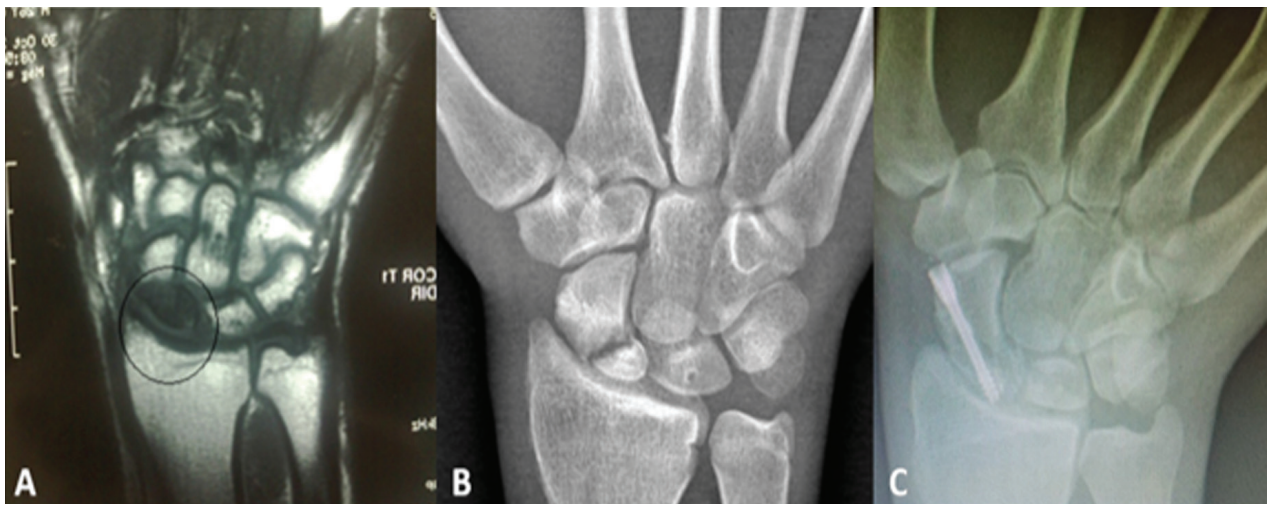

Figure 1. This figure shows: A) Pre operative MRI of a patient of Group B; B) Pre operative AP X-Ray of a patient of Group B; C) Post operative (5 months) X-Ray of a patient of Group B

in group B ($p<0.05$). In Group B all nonunion sites healed primarily at an average time period of 3.2 ± 1 months (Figure 1).

Statistical analysis showed a significant difference ($p<0.001$) about the preoperative and the postoperative VAS and Mayo Wrist Score evaluation in both groups at 6 and 12-month follow-up, moreover we recorded a statistical difference between groups at the 6-month and 12-month follow-up ($p<0.05$) (Table 1). At the donor site, the mean VAS score was 2 ± 2.1 at seven days post operatively. The time to return to normal walking activity was 2 days (range 1-4).All patients restore the full ROM at 7 days post surgery.

Table 1. Statistical analysis showed a significant difference ($p<0.001$) about the preoperative and the postoperative VAS and Mayo Wrist Score evaluation in both groups at 6 and 12-month follow-up, moreover we recorded a statistical difference between groups at the 6-month and 12-month follow-up ($p<0.05$)

	Group A	Group B
Preoperative Mayo Wrist Score	33±8.6	30±5.6
6 Months Mayo Wrist Score	70.51±3.7	79.51±3.63
12 Months Mayo Wrist Score	79.65±3.5	90.47±2.9
Preoperative VAS	7.2±1.5	7.05±2
6 Months VAS	4.1±1	2.11±2
12 Months VAS	2.9±1	1.5±1.16

Discussion and Conclusion

The most important finding of the present study is that the free flaps showed better clinical and radiographic results for the surgical treatment of proximal pole necrosis in scaphoid nonunions.

In fact despite the good results of the bone graft, the flaps seems to be preferable in the treatment of these nonunions.

The corticoperiosteal flap is a microsurgical technique that can be performed only by expert microsurgeons. The traditional grafts like the free fibular can be used to treat larger defect, for this reason their use in case of minimal bone loss is still discussed. The medial femoral condyle flap provides a source of corticoperiosteal vascularized bone that does not require the harvest of a major vessel. Because of its thickness (0.5-1 mm), it seems that the flap can be rapidly harvested and tailored to numerous shapes and configurations as required for various osseous defects. The great osteogenic capacity of this flap has been frequently demonstrated by different authors: Sakai has shown that the periosteum is osteogenic, however when harvested as an isolate layer it failed (14). The proposed reason for this unreliability is the injury of the to the cambium layer, which lies between the periosteum and cortex of the bone (14, 15). The preservation of this layer increases local bone mass within the recipient

site, enhancing graft incorporation. This fine layer is easily injured when the periosteum is separated from the cortex. Doi and Sakai (14) described elevating the periosteum along with a thin strip of cortex, thus protecting the delicate and vital cambium layer. We believe that the cortico-periosteal is the only microsurgical bone flap with those proprieties. After their introduction different Authors described the clinical implications of the corticoperiosteal flap: Fuchs et al. (13) reported bone healing in 3 patients with atrophic nonunion of the clavicle that were healed by free vascularized corticoperiosteal bone grafts. More recently, Choudry et al. (16) reported excellent results in the treatment of 12 bone nonunions. In that series 75% of the nonunion sites healed primarily without complication, 25% healed secondarily following implant modification. Similar success rates have been reported by Muramatsu et al. (17) in their treatment of 10 humeral nonunions. In our study 100% of unions were achieved at a mean length of 3.2 months. Patients showed a remission of functional pain and disability at the previous nonunion site with return to normal daily activities. In fact, the clinical evaluation showed a significant improvement of pain and disability of the upper limb starting on the 6-month follow-up compared to the preoperative clinical condition and compared with the control group. The 12-month follow-up revealed a substantial maintenance of pain and functional improvements. These clinical data are very interesting if combined with the radiographic results, in fact, in our study, the unions occurred after an average time of 3.2 months after surgery, highlighting a correlation between the bone healing and the pain and clinical scale improvements. Although reports are still limited, the corticoperiosteal flap is the only surgical treatment with a success rate close to 100% and a limited donor defect. One of the possible explanations of the minimal morbidity of the donor site is related to the surgical technique. In fact the surgical access to the medial condyle is between the natural cleavage of the vastusmedialis and the adductor longus. Moreover, thanks to the intrinsic features of the bloody supply of the medial condyle, the graft harvesting does not cause ischemia, in fact in the condyle the flow is centrifugal from the medullary to the cortex (18-22). An other important advantage of this technique is that the anatomy and biomechanics of the donor site are not compromised. Katz et al. (21) in 2012 ssessed the axial stability of the femur after harvesting corticocancellous flaps. Authors demonstrated that, when stressed with supraphysiologic forces, the femur retains its axial stability even after harvesting of large corticocancellous flaps (up to 24 cm) from its medial aspect. In our study, no postoperative radiographic changes at the donor site were documented; there were no cases of ROM limitations and patients return to normal walking activity in 2 days. We do not report cases of persistent knee pain. Compared to other bone graft the corticoperiosteal flap showed less complications at the donor site: chronic (> 6 months) donor site pain, dysesthesias around the incision area, iatrogenic nerve injuries, superior gluteal artery injuries, iliac fractures and hernias, are reported in case of iliac crest bone graft (23,24). While, chronic pain, dysesthesias around the incision area, instability and limited range of motion in the ankle, sensory deficit, claw toe, dorsiflexion of the great toe are reported in case of vascularized fibula graft (24). In fact, compared with traditional grafts the corticoperiosteal graft allows a faster healing of fractures with a minimal morbidity at the donor site. At our knowledge this flap is the only microsurgical procedure, in orthopaedic surgery, that can be performed not only as a rescue technique but also as a treatment of first choice in case of scaphoid nonunions.

At our knowledge, these flaps are a valid surgical technique for the treatment of proximal pole necrosis in scaphoid nonunions.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Micro-fragmented Adipose Tissue Transplantation (MATT) for the treatment of acetabular delamination. A two years follow up comparison study with microfractures

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Summary. *Background:* Delamination of acetabular articular cartilage is a common progressive abnormality in hips with femoroacetabular impingement. The aim of this study is to compare the effectiveness of two different procedures for the arthroscopic treatment of acetabular delamination: microfractures (MFx) and micro-fragmented autologous adipose tissue transplantation (MATT) technique. *Methods:* We carried out a controlled retrospective study of 35 patients affected by an acetabular cartilage delamination in femoroacetabular impingement (FAI). In all the selected cases the size of the defect ranged from 1 to 2 cm^2, with a mean size of 1.9 cm^2 in MFx group and 1.6 cm^2 in MATT group (p=0.1). Of these, 18 patients were treated with MFx while 17 patients were treated with MATT. The two groups were similar in terms of clinical, functional and radiological aspects. All the patients were assessed before and after the procedure, for pain and function, with the modified Harris Hip Score (mHHS). The mean preoperative mHHS was 50±5 for MFx group and 53±6 for MATT group (p = 0.245). All the patients were followed-up for two years. *Results:* The final mHHS was 76±12 in MFx group and 97.1±3 in MATT group (p<0.001). In both groups neither a conversion to total hip arthroplasty nor a revision hip arthroscopy was observed. *Conclusions:* The results of this study provide proof that MATT technique improves clinical outcomes with a mHH scoring significantly higher than MFx group. (www.actabiomedica.it)

Key words: hip arthroscopy, cartilage defect, FAI, Lipogems®, microfractures

Introduction

Treatment of hip cartilage disease is challenging and there is no clear algorithm to address this entity. With the growth of surgical skills in hip arthroscopy, cartilage restoration techniques are evolving in a fast and exponential manner (1). Biological and surgical treatments have been proposed to treat these pathologies. Biological treatments include platelet-rich plasma, stem cells or bone marrow aspirate concentration, hyaluronic acid and others (2-6). Surgical treatments include debridement, microfracture, autologous chondrocyte implantation, matrix-induced chondrocyte implantation, autologous matrix-induced chondrogenesis, mosaicplasty, osteochondral allograft transplantation and stem cells, injected or implanted in a matrix (stem cells in membranes/expanded stem cells) (7-20).

Cell-based therapies using either chondrocytes or mesenchymal stem cells (MSCs) represent an appealing alternative strategy. Different protocols of intra-articular MSCs injection have been studied to treat chondral injuries in large animals such as sheep, pigs and horses. According to these interesting preclinical

results, support for MSCs-based therapies in clinical practice have been provided (21).

Recently some Authors reported on intra-articular injection of MSCs into the knee for the treatment of focal defect or more generalized cartilage loss in osteoarthritis, showing interesting results regard pain and clinical outcome (22).

The aim of this retrospective study is to compare two kind of treatment for acetabular delamination associated to Femoro-Acetabular Impingement (FAI): microfractures (MFx) and micro-fragmented autologous adipose tissue transplantation (MATT) technique.

The treatment differs in that the MFx technique involves making multiple holes (microfractures) into the subchondral plate at the site of the chondral defect, allowing bone marrow derived pluripotent cells to fill the damaged area. The MATT procedure contrarily, after harvesting the subcutaneous adipose tissue from the perithrocanteric area of the operated hip, incorporates MSC into bioactive units that are injected into the joint to cover the chondral defect, in a single arthroscopic surgical step.

Materials and methods

From 2007 to 2015 we carried out 249 hip arthroscopies in patients where an acetabular delamination was associated with FAI. Chondral defects have been treated with MFx (in 58 cases) or MATT (in 91 cases).

The institutional review board of the involved hospital decided that no ethical approval was necessary as it was thought that for this retrospective study the informed consent of the patient was sufficient. This research has been ethically conducted according to the World Medical Association Declaration of Helsinki.

In order to select two homogeneous groups, to compare outcomes obtained using the two different techniques, we applied stringent inclusion and exclusion criteria.

The inclusion criteria were: patients with symptomatic FAI; acetabular delamination; lesion size from 1 to 2 cm^2; less than grade 1 in degenerative radiological changes (Tonnis scale); patients' age between 18 and 60 years; a minimum follow up of two years.

The exclusion criteria were: osteoarthritis (OA) secondary to hip developmental diseases (developmental hip dysplasia, Perthes disease, slipped capital femoral epiphysis); autoimmune disease; avascular necrosis (AVN); coxa profunda; protrusio acetabuli; any other associated complementary surgical treatment as collagen membranes implantation or fibrin glue and bone marrow stem cells injection.

In determining criteria used to select the patients our objective was to obtain two homogeneous groups in terms of age, clinical aspects and degree, area and localization of chondral lesion.

Patients who strictly met inclusion and exclusion criteria were 35, reviewed retrospectively and divided in two groups (Table 1):

- A) 18 patients treated with arthroscopic MFx (12 male, 6 female) with a mean age at surgery of 36±13 years (range 19-59) and a mean lesion size of 1.9±0.3 cm^2 (range 1-2 cm^2); in this group the FAI classified as Cam in 13 cases, Pincer in four cases and combined in one case.
- B) 17 patients were treated with arthroscopic MATT (9 male, 8 female) with a mean age at surgery of 35±9 years (range 22-54) and a mean lesion size of 1.6±0.5 cm^2 (range 1-2 cm^2); in this group the FAI classified as Cam in 12 cases, Pincer in two cases and combined in three cases.

All patients took standard antero-posterior (AP) X-ray of the pelvis, AP view and cross-table view of the affected hip preoperatively; an MRI (Magnetic Resonance Imaging) and e CT (Cumputed Tomography)-scan with a 3D reconstruction of the affected hip was performed to diagnose the labral injury, chondral de-

Table 1. Characteristics of patients enrolled

	MFx	MATT
n°	18 (6 F/12M)	17 (8 F/9 M)
Mean age	36±13 (range 19-59)	35±9 (range 22-54)
Acetabular chondral lesion (cm^2)	1.9 ± 0.3 (range 1-2)	1.6 ± 0.5 (range 1-2)
FAI	13 Cam 4 Pincer 1 combined	12 Cam 2 Pincer 3 combined

fects, bone deformities and other intra and extra articular pathologies.

The modified Harris Hip Score (mHHS) was administered to all patients before surgery (T0) and postoperatively at six months (T1), one year (T2) and at final two years follow-up (T3).

Surgical technique

All hip arthroscopies were performed by the same operator (AF). The patient was positioned in lateral decubitus, under combined anesthesia (spinal anesthesia and deep sedation). The affected hip was prepared and draped in the usual sterile fashion, and traction was applied to open the joint space. A first supra-throcanteric and a second anterior-supra-para-throcanteric portal were used. The first portal was performed under image amplifier guidance, while the second under direct arthroscopic visualization. A 70° arthroscope was used. To treat FAI deformities was performed an arthroscopic femoral head and/or acetabular rim resection, and any detached labrum was reattached to the acetabular rim with suture anchors while any fibrillar deterioration of the labrum was treated with radiofrequencies. Acetabular delamination was detected and localized by using an arthroscopic probe. The wave or carpet sign was defined as the major arthroscopic evidence of the delaminated area. Any detachment of the chondral fibrous mantel from the subchondral bone was assessed. In cases where the subchondral bone was exposed, the chondral defect was classified as a flap lesion and not as a delamination. The delaminated area was topographically localized according to the mapping system illustrated in Fig. 1.

MFxs were arthroscopically performed using a 30° or 60° degree angled awl, carefully inserted in between the subchondral bone and the fibrous chondral layer. The subchondral surface was therefore traumatized or scratched by hammering the awl, in order to allow the bleeding. Maximum care was taken not to interrupt the delaminated layer (Fig. 2).

The MATT procedure was as well performed as a single arthroscopic surgical step. About 40 ml of subcutaneous adipose tissue was harvested from the perithrocanteric area of the operated hip by manual liposuction. Mild mechanical forces were applied using a completely closed system (Lipogems®), avoiding enzymes, additives, and other manipulations. The harvested tissue was therefore manually microfragmented in order to remove blood and oil residuals and washed with saline solution. The product obtained (the transplant), of about 7 ml, incorporates MSC into bioactive units (23). One needle was inserted in between the subchondral bone and the fibrous chondral layer and the transplant injected directly in the delaminated area, after removing the arthroscopic fluids from the joint (Fig. 3).

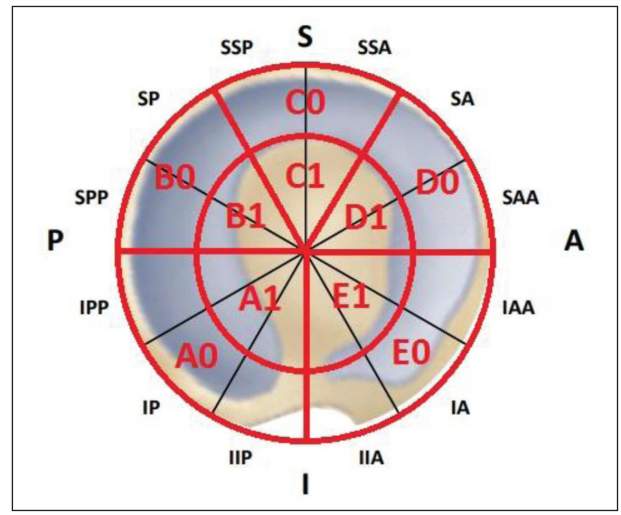

Figure 1. Acetabular topographic localization mapping system

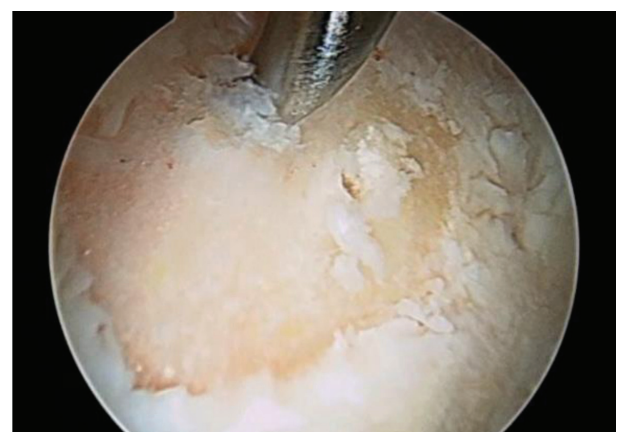

Figure 2. Intra-operative image of MFx. Subchondral bone was perforated by hammering the awl to allow bleeding

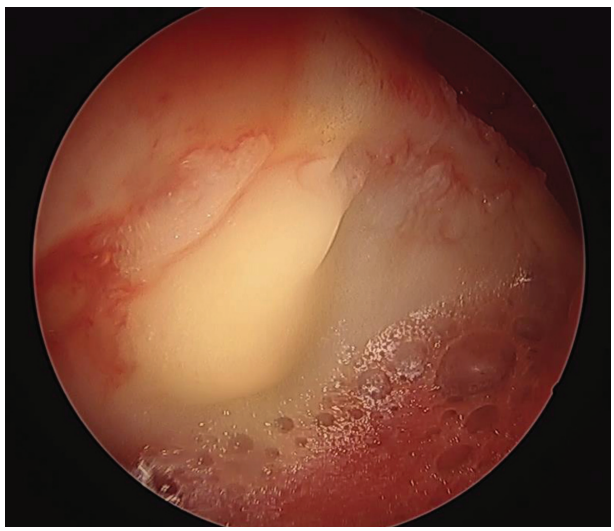

Figure 3. Intra-operative image of MATT. Lipogems® injected directly in the delaminated area by a needle after water suction

Postoperative and Rehabilitation Protocol

Postoperatively the patients in both groups followed the same rehabilitation program.

Isotonic and isometric quadriceps and gluteus contractions started the first postoperative day as well as continuous passive motion, from 0°-40° to 0°-90° of flexion with a daily increase of 10°. Walking was allowed with the aid of two crutches with partial weight-bearing (30% of body weight) on the operated leg for three weeks. From post-operative day two, patients started gym bike up to speed "0" 15 minutes three times a day, and active exercises to regain the full range of motion. Swimming freestyle or on the back was allowed after two weeks. At four weeks post-op, walking with the aid of one crutch opposite to the treated leg was allowed for seven days, then normal walking thereafter.

Resumption of normal work activities became possible 2/4 weeks after surgery. Impact sport activities could resume at three months post-op and complete return to sport activities was allowed six months after surgery.

Statistical analysis

The data from this study was analyzed through the use of the SPSS statistics software program (SPSS Inc. Chicago, USA). A t test was used for normally distributed, continuous variables. The Mann-Whitney U test was applied for continuous variables, which were not normally distributed.

A p value <0.05 was considered statistically significant. Descriptive statistics are presented as mean (±SD).

Results

The median preoperative (T0) mHHS was 50±5 for MFx group and 53±6 for MATT group. Both increased at six months (T1) to 79±7 for MFx and 90±13 for MATT, and at one year (T2) to 79.4±11 for MFx and 96.8±3 for MATT.

At follow-up of two years (T3) we observed a progressive reduction of functionality in MFx group with a mHHS of 76±12 while in the MATT group mHHS score increased to 97.1±3.

In both groups neither a conversion to total hip arthroplasty nor a revision hip arthroscopy was observed. No major complications or infections were reported in both groups.

Differences in outcomes between the two groups were significant at T1 (p=.003), T2 and T3 (p<0.001) while there are no statistically significant differences at T0 (p=.245) (Table 2; Fig. 4)

Table 2. Results

mHHS	MFx	MATT	p
T0	50±5	53±6	.245
T1	79±7	90±13	.003
T2	79.4±11	96.8±3	<0.001
T3	76±12	97.1±3	<0.001

A p-value <0.05 was considered statistically significant.

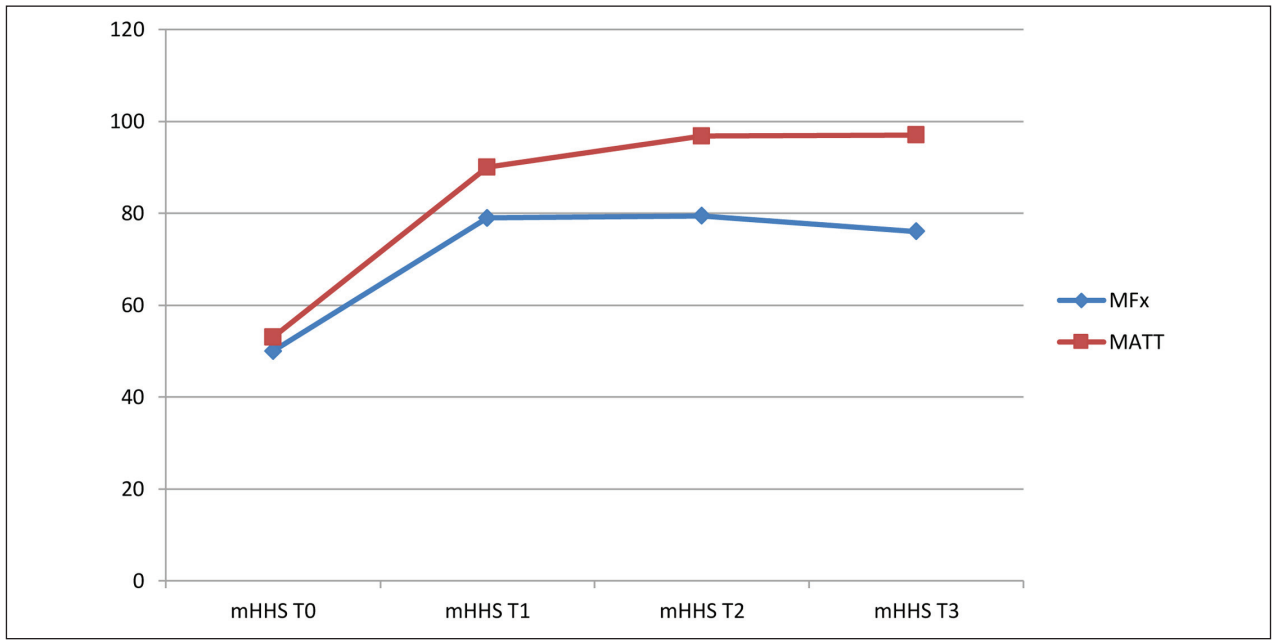

Figure 4. Evolution of clinical and functional scoring (mHHS) in two treatment groups (MFx Vs MATT)

Discussion

This is the first study to compare clinical outcomes of using MFx and MATT in treatment of FAI-induced early acetabular chondral lesion (24).

We know that when compromised cartilage is associated with FAI, treatment which targets both pathological processes gives a better outcome (25), but anyway very few data are present in literature about chondral lesions of the hip and their treatment, and even less showing differences between two or more kinds of treatment (8).

Several arthroscopic techniques have been used to treat hip chondral lesions, as an example the use of stem cells has been reported in preclinical studies (26), but only few studies report valuable outcomes (7). Therefore comprehensive evidence-based guidelines for the treatment of chondral lesions of the hip remain to be defined (27-29).

MFx is still the treatment of choice for small chondral defects of the acetabulum and femoral head (30). Satisfactory clinical results after MFx for lesions in the hip, including those in athletes, have been recently reported (31). Although MFx has been shown to be effective in management of lesion measuring less than 2 cm^2 in the knee, deterioration in the function of the knee in 47% and 80% of patients after a mean of two years has been reported in an evidence-based systematic analysis assessing a total of 3122 patients (7 to 1200) (32). In the hip also the worst results were recorded in cases with chondral defect equal to or greater than 3 cm^2 (8, 33).

These are the reasons why we strictly respected the inclusion criteria illustrated, enrolling exclusively patients with chondral defect equal to or inferior than 2 cm^2, with no statistically significant differences in lesion size in the two treated groups (p=0.1).

In our study MATT appears to give more satisfactory results. This technique exploits the regenerative potential of mesenchymal progenitor cells deriving from adipose tissue. In addition the microfragmentation of adipose tissue provides bio-active units able to supply the regenerating with a proper microenvironment which support cells adhesion, growth and differentiation (23).

Our results demonstrate a better outcome of MATT technique compared with microfractures at a short-median follow up. This demonstrates as well an intrinsic lack of biological effectiveness in the microfractures technique, that must be carefully considered

in our treatment options, especially in athletes or very young and active patients.

Our results are exclusively based on clinical data and this must be considered as a limitation. Postoperative MRI evaluation of the chondral defects could have been helpful in clarifying results, as well as a histological evaluation.

In our opinion this study also has two major limitations: firstly it was a retrospective observational not randomized study, secondly our clinical outcomes were evaluated using only one validated score system (mHHS).

Conclusion

The results of this study provide proof that MATT therapy improve clinical outcomes. The MATT group showed durable improvement at follow up of two years, with a scoring significantly better than MFx group, in which was observed a sensible reduction of the clinical scoring also.

However further studies involving even more patients with larger follow-up and others clinical and functional scores may be necessary.

The work was done at COF Lanzo Hospital, Ortopedia 1, Lanzo d'Intelvi (Co) 22024, Italy

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Pelvic ring fractures: what about timing?

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Summary. *Background and aim:* Pelvic ring fractures represent a challenge for orthopaedic surgeon. Their management depends on patient's condition, pattern of fracture and associated injuries. Optimal timing for synthesis is not yet clear. The aim of this study was to define if surgical timing influenced clinic and radiographic outcomes following open reduction and internal fixation for Tile B and C fractures. *Materials and methods:* 38 patients were included. Patients underwent a clinical examination with the Majeed Score, Iowa Pelvic Score and Orlando Pelvic Score. The radiographic assessment was performed according to Matta Pelvic Score. A statistical analysis of the data compared patients who were operated within 3 weeks (group 1) and those operated later (group 2). *Results:* Both clinical and radiological outcomes were influenced by timing of surgery. *Conclusion:* Pelvic ring fractures interest many polytrauma patients and, therefore, their surgical orthopedic approach is frequently delayed as consequence of the severity of the associated clinical conditions. An early surgery of pelvic rong fractures allows a better quality of reduction and osteosynthesis. (www.actabiomedica.it)

Key words: pelvis, fracture, injury, timing, fixation, surgery

Introduction

Pelvic ring fractures (PRFs) are rare injuries which occur with a frequency of approximately 20-37 per 100.000 population (1,2) and represent up to 6% of all fractures (3-5).

PRFs are often caused by high energy traumas, such as road traffic accidents (50%), work accidents (30%) and falls from high (15%). They are described in up to 20% of polytrauma patients and are associated with high mortality and severe morbidity; mortality in fact ranges from 8% to 32% and it is mostly caused by vascular (50%) and urinary injuries (30 %) (7).

Up to 22% of all pelvic fractures are hemodynamically unstable and for this reason their treatment requires a multidisciplinary team approach including the general, vascular and orthopedic surgeon, anesthesiologist and interventional radiologist (8-10), which together have to manage injuries of different districts.

Consequently, orthopedic definitive treatment is often delayed. Optimal timing for fixation is not yet clear but recent guidelines suggest that open reduction and internal synthesis within 21 days is associated with a higher percentage of excellent reductions and better long-term results (11).

The aim of this study was to define if surgical timing influenced clinic and radiographic outcomes following open reduction and internal fixation (ORIF) for Tile B and C fractures (12-15).

Materials and methods

Patients who underwent ORIF for Tile B and C PRFs between January 2010 and January 2018 were included in this retrospective trial with a minimum follow-up of 1 year. Each case was identified from an information database at the University Hospital of

Parma. Patients in whom charts or radiographs were unavailable or incomplete were excluded. Other exclusion criteria were open fractures and concomitant acetabulum or columns fractures.

Age, gender, mechanism of injury (low/high energy trauma), fracture classification according to Tile and surgical characteristics (quality of reduction and surgical timing) were extracted from the database and registered.

A functional evaluation of all subjects was performed at follow-up (mean 4.3 years; min. 1 and max. 9) through the Majeed Pelvic, Iowa Pelvic and Orlando Clinic Pelvic Score (16-18).

A radiological analysis was done by an indipendent observer (ML) using antero-posterior, inlet and outlet views performed immediately after surgery and at follow-up. Each radiograph was assessed according to Matta Pelvic Score in order to classify the quality of reduction (19).

All data were entered into a database (Microsoft Excel). Descriptive statistics (mean, percentage and ranges) were calculated. The Mann-Whitney U test was used to compare the two groups. Statistical analysis was undertaken using SPSS for Windows. Statistical significance was defined as p value of <0.05.

Results

Thirty-eight patients respected the inclusion criteria and all underwent to ORIF. Twenty out of 38 (group 1) were operated within 21 days from trauma and 18 were surgically treated later (group 2).

In group 1 6 (30%) were females and 14 (70%) males and in the second group 3 (16.7%) were females and 15 (83.3%) males. The mean age at the time of injury was 40 years in group A (25-60) and 42 in group B (30-61). An high energy trauma was described in 75% of cases in group 1 and in 82% of group 2.

In group 1 the mean time between injury and surgery was 10 days (min. 5 max. 20) and in the second group was 24 days (min. 21 max. 30).

In group 1, 15 patients had Tile B1 fracture (Figure 1), 1 Tile B 2 and 4 Tile C1; in group 2 10 fractures were Tile B1, 1 Tile B2 and 7 Tile C1 (Figure 2).

In group 1 the average Majeed Pelvic Score was 86/100, the average Iowa Pelvic Score was 71/90 and the mean Orlando Pelvic Score was 22.3/30. In group 2 these results were respectively 63.17/100, 59.50/90 and 17.33/30. There was a statistically significant difference among the two groups for all the scores (p=0.002, p=0,004, p=0,032) (Figure 3A, 3B, 3C).

Radiological evaluation was in line with the clinical results and showed better reduction in group 1 (70% of cases with anatomic or excellent reduction) compared to group 2 (40% of cases with anatomic or excellent reduction) (p=0.047). This situation was similar immediately after surgery and at follow-up (Figure 4).

Discussion

PRFs occur mainly in polytrauma patients and their presentation can be critical given the association with high energy traumas, haemodynamic instability and life threatening injuries.

Mortality, which is caused mainly by vascular and urinary injuries, is reported in up to 32% of cases (7) and those which require resuscitation are described in up to 25% of subjects (8-10). For this reason the best management of such injuries is based on a multidisciplinary approach which includes general, vascular and orthopedic surgeon, anesthesiologist and interventional radiologist, which together have to treat injuries of different districts.

In the past the majority of PRFs were managed non operatively. In Tile A lesions conservative treatment was associated to satisfactory results (20-22). This is not valid in Tile B and C patterns (23-26). Multiple studies in fact have shown the persistence of pain and reduced function in patients with residual deformity of the posterior pelvic ring greater than 1 cm (23,26) and poorer functional outcomes. For these reasons ORIF is the treatment of choice in the majority of these more severe injuries. A systematic review by Papakostidis et al. (23) found that Tile B and C PRFs treated with operative fixation had a higher union rate and a better quality of reduction that nonoperatively managed fractures. Gait disturbance was also found to be more common in nonoperatively managed cases. So a definitive fixation is necessary, and should be performed early.

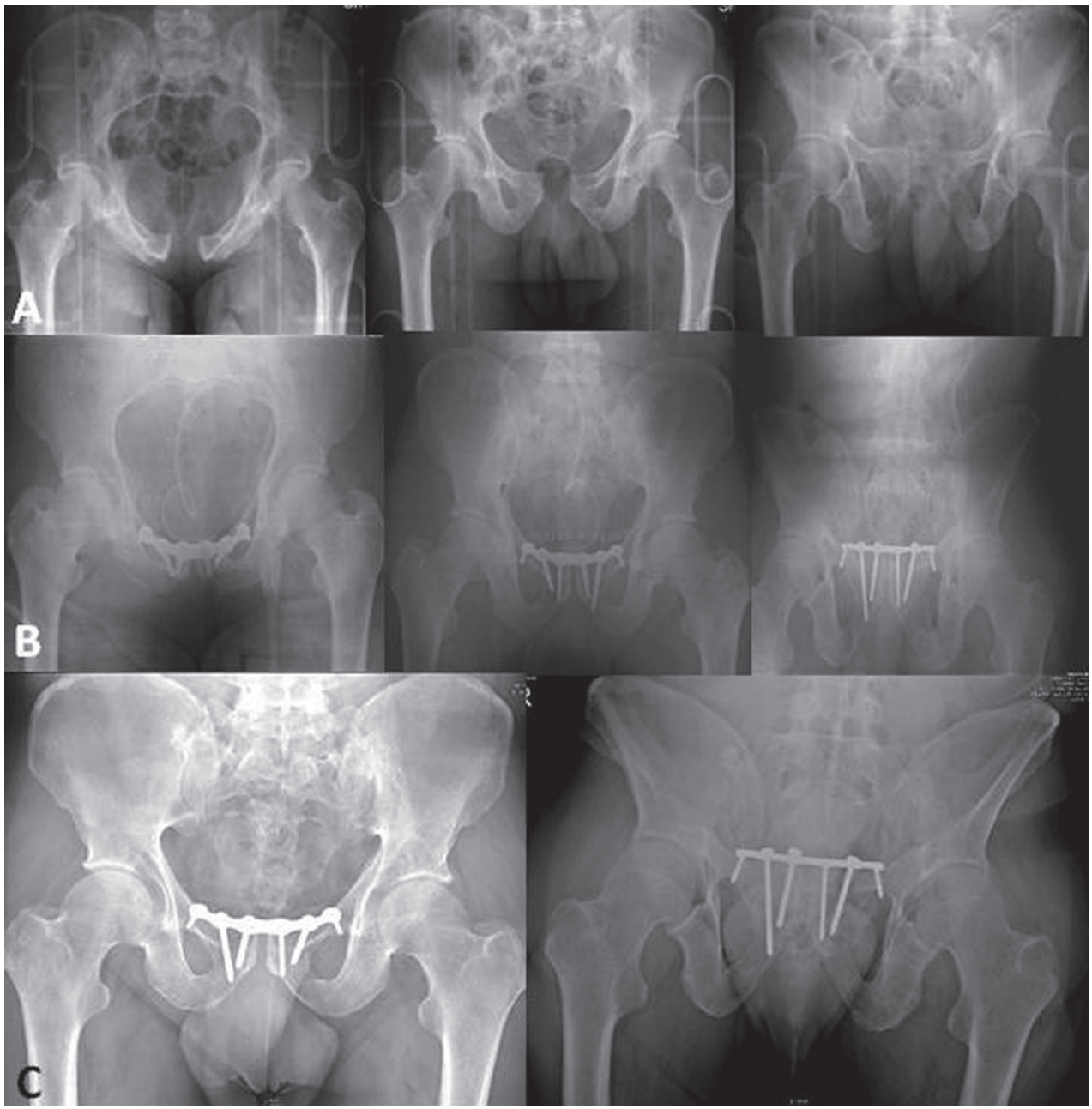

Figure 1. Tile B1 PRF in a patient of group 1. A; preoperative x-rays. B; postoperative radiographs with anatomical reduction. C; x-rays 2 years after trauma with the same quality of reduction

The definition of the length in time of that early period is really difficult and optimal timing of synthesis is not yet clear. The definitive pelvic fixation is necessarily often delayed and it depends on the response to resuscitation, the type of associated injuries and the immune-inflammatory status of the patient. Recent evidences suggest to treat PRFs almost within 3 weeks from trauma (11). This timing facilitates reduction and stabilization of the fractures, thus guaranteeing better long-term outcomes (11).

This study confirms these assumptions. In fact, better clinical and radiological results have been observed in those patients in which fixation was performed within 21 days from trauma.

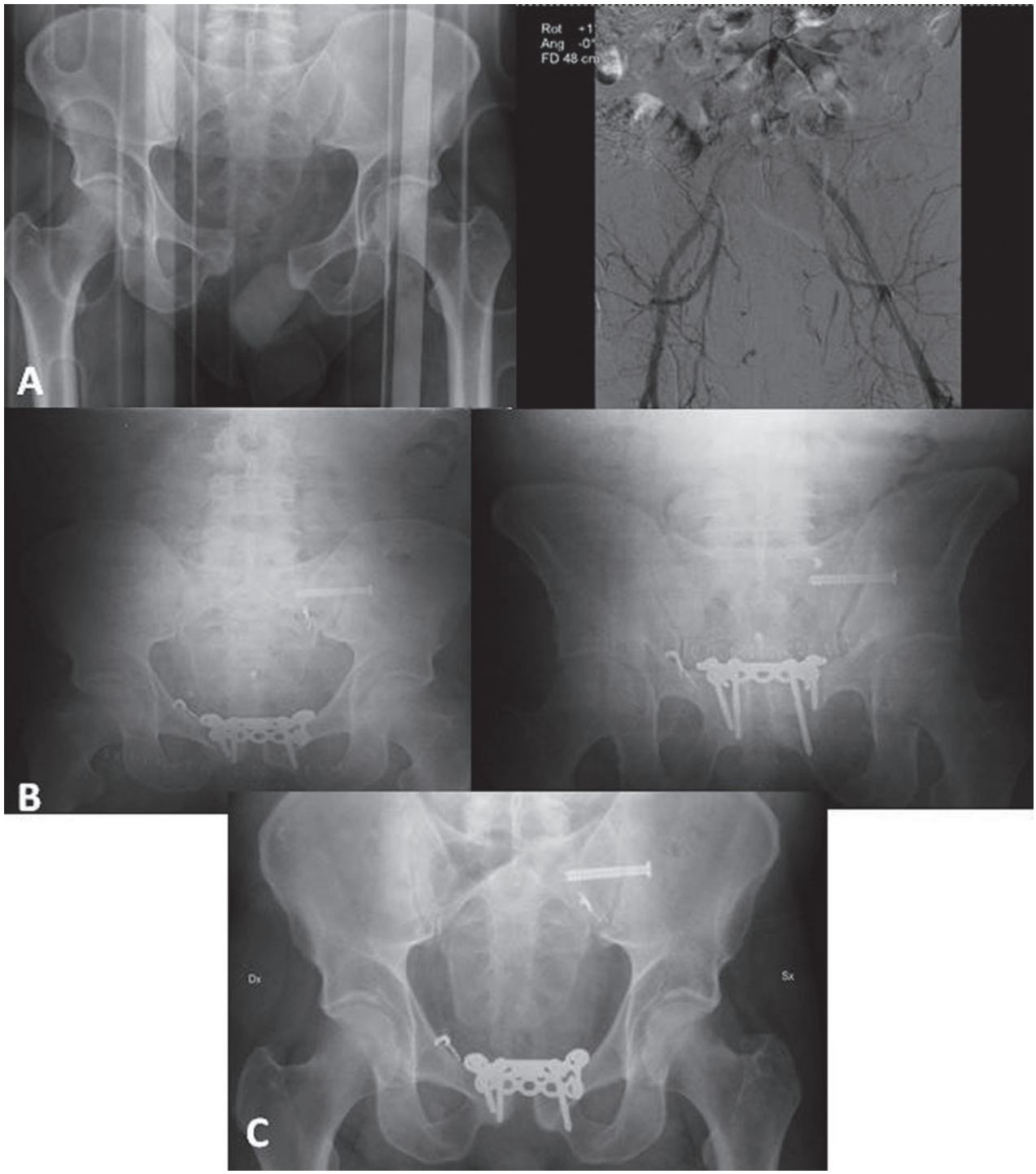

Figure 2. Tile C1 PRF in a patient of group 2. A; preoperative x-ray and arteriography for embolization of the sacral branch of the left hypogastric and of the right epigastric artery. B; postoperative radiographs considered imperfect according to Matta Pelvic Criteria. C; x-ray 1 year after trauma

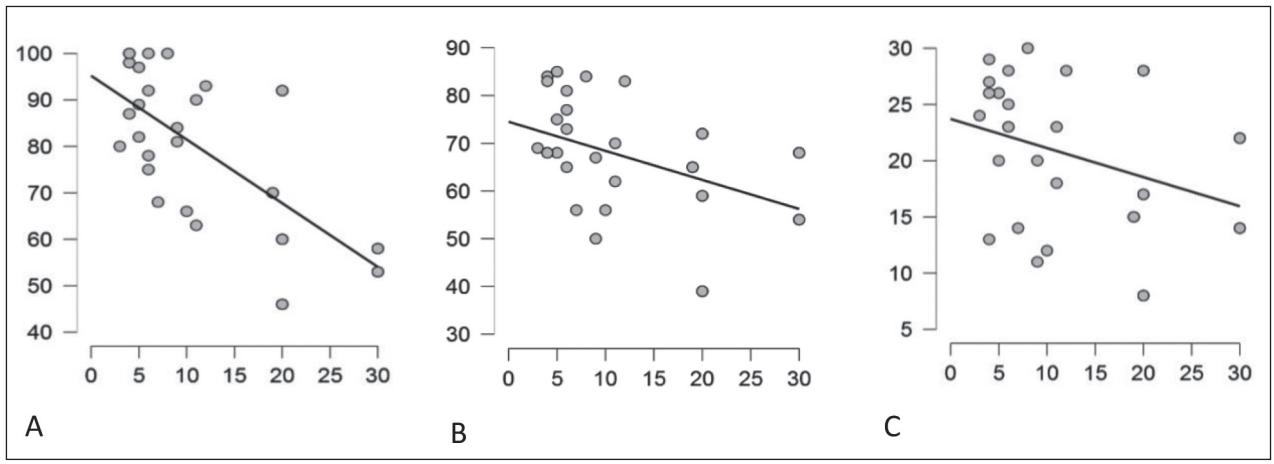

Figure 3. A. Majeed Pelvic Score. B. Iowa Pelvic Score. C. Orlando Clinic Pelvic Score. Distribution of the scores in relationship to timing of surgery. Better clinical results are observed in early surgery.

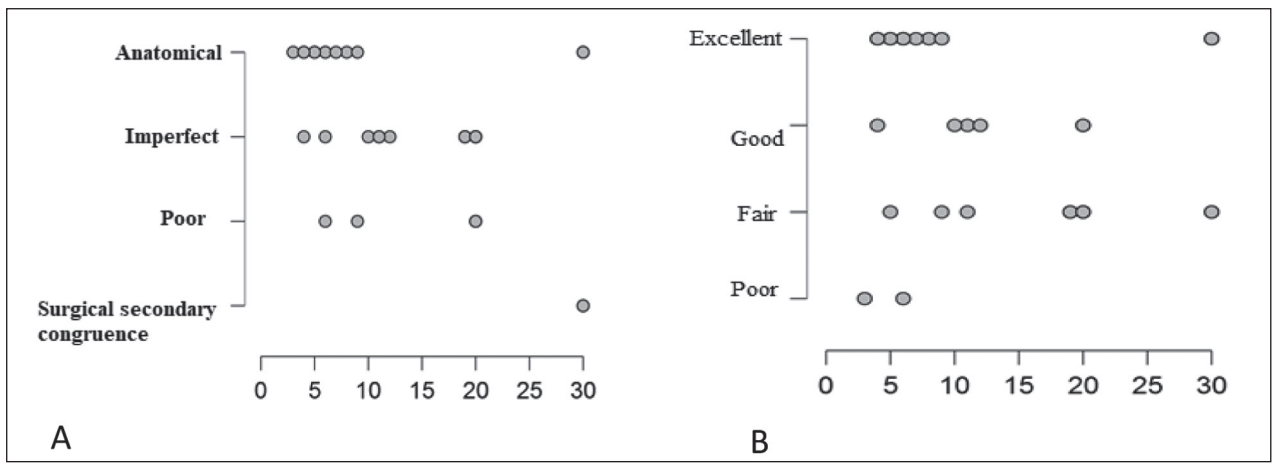

Figure 4. Postoperative (A) and at follow-up (B) radiographic evaluation. Similar distribution in A and B; better results in early surgery

Conclusions

The results observed in the present study underline that an early orthopedic surgical treatment in PRFs guarantees better clinical and radiographic evolution. Associated severe clinical conditions can delay the definitive pelvic fixation which should be performed within 3 weeks from trauma.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Preliminary experience with MEDGAL DHS for treatment of proximal femoral fractures

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Summary. *Background and aim of the study:* The Authors report their implant's analysis and preliminary experience with a new fixation device, the MEDGAL DHS for treatment of proximal femoral fractures, producted by MEDGAL Sp.z o.o, Niewodnicka, Poland. *Materials*: Between January 2019 and September 2019 in Orthopedics and Traumatology Department of Piacenza, 12 patients with stable pertrocanteric fractures were treated with the MEDGAL DHS. *Results:* No patients presented perioperative complications with low bleeding and mean surgical time of 40 minutes. *Conclusions:* DHS is an optimal implant for the treatment of stable pertrochanteric femural fractures. (www.actabiomedica.it)

Key words: pertrochanteric fractures, DHS, MEDGAL DHS

Introduction

Femoral fractures are one of the most common fractures encountered by orthopaedic surgeons across the globe (1). Intertrochanteric (IT) fractures are a common subtype of these and occur mostly in elderly patients with multiple co-morbidities, including osteoporosis (2), while in young adults, these fractures are generally due to high energy trauma, such as road accidents (3).

These type of fractures usually occur between the greater trochanter, the attachment site to the hip abductor and extensor muscles, and the lesser trochanter, the attachment site of the hip flexor muscle (4). The incidence of hip fractures is 2-3 times more common in females and the risk of fracture will double, every 10 years after the age of 50 (5).

The Dynamic Hip Screw (DHS) is a screw that allows for controlled dynamic sliding of the femoral head and is used to fix both the femoral head and the device to the shaft of the femur. The dynamic compression allows the weight-bearing stresses to stabilize the femur so that it may undergo remodelling and proper fracture healing (6).

Materials and Method

Twelve patients (7 female and 5 male) with stable intertrochanteric fracture of the femur (AO Classification 31 A 1) have been treated with MEDGAL DHS between January 2019 and September 2019 at Orthopedics and Traumatology Department, Guglielmo da Saliceto Hospital, Piacenza, Italy.

The youngest patient was 70 years of age and the oldest was 83 years with the mean age being 76 years.

One patient had an outcome of pregressive acetabular fractures ipsilateral of the pertrocantheric fracture.

The MEDGAL DHS is made of a titanium alloy ISO 5832-3 coated in silicon; silicon inducing bone attachment to metallic implants. In addition, these coatings are non-resorbable, and are thus suitable for long-term implantations.

These implant is available in a wide range of size and barrel angle (130°, 135°, 140°, 145°, 150°), for varied clinical situations.

The MEDGAL DHS have the possibility to have two different diameter of lag screw: 12.5 mm and 16 mm for the osteoporothic bone.

The surgical technique employed a lateral approach to the hip: the tensor fascia lata was incised and the vastus lateralis muscle was retracted, followed by an L-shaped incision into the vastus lateralis muscle. Anatomical reduction was achieved. Guide wire insertion was done below the centre in the anteroposterior fluoroscopic image and central in the lateral fluoroscopic image. Reaming was done and appropriate size lag screw was inserted, side plate was fixed with insertion of the screws. Usually a five-hole long barrel plate (130°, 135°) was used in almost all our cases (Fig. 1-2).

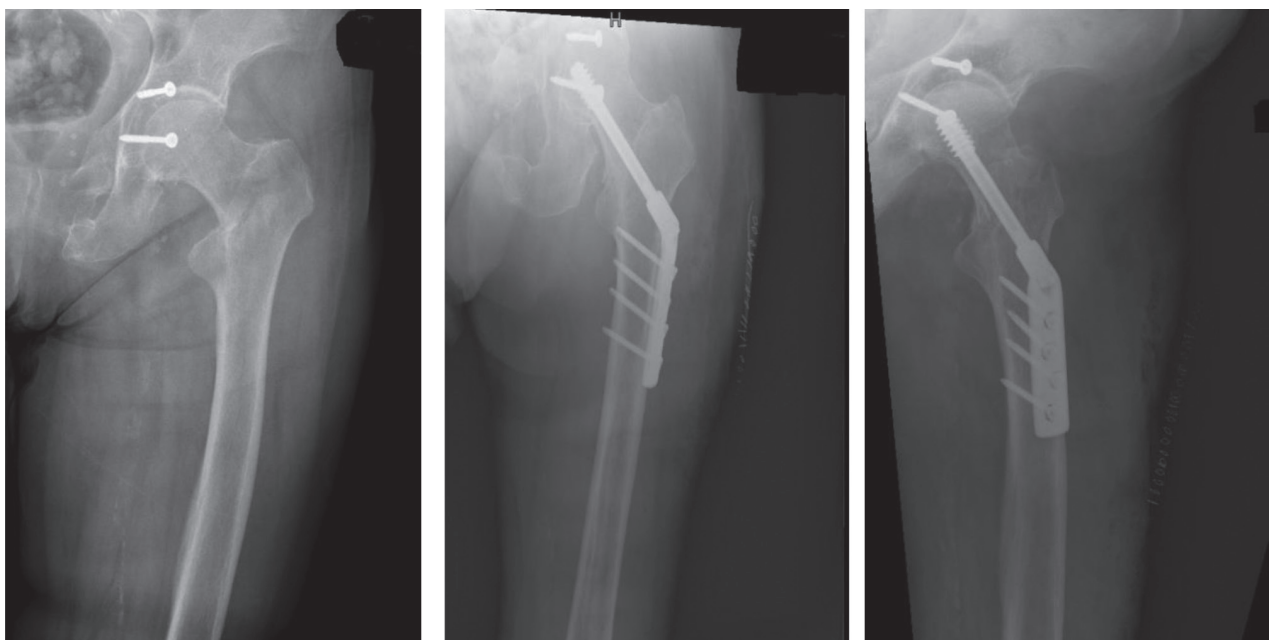

Figure 1. Pre and postoperative Rx images of the patients with a pregressive acetabular fractures

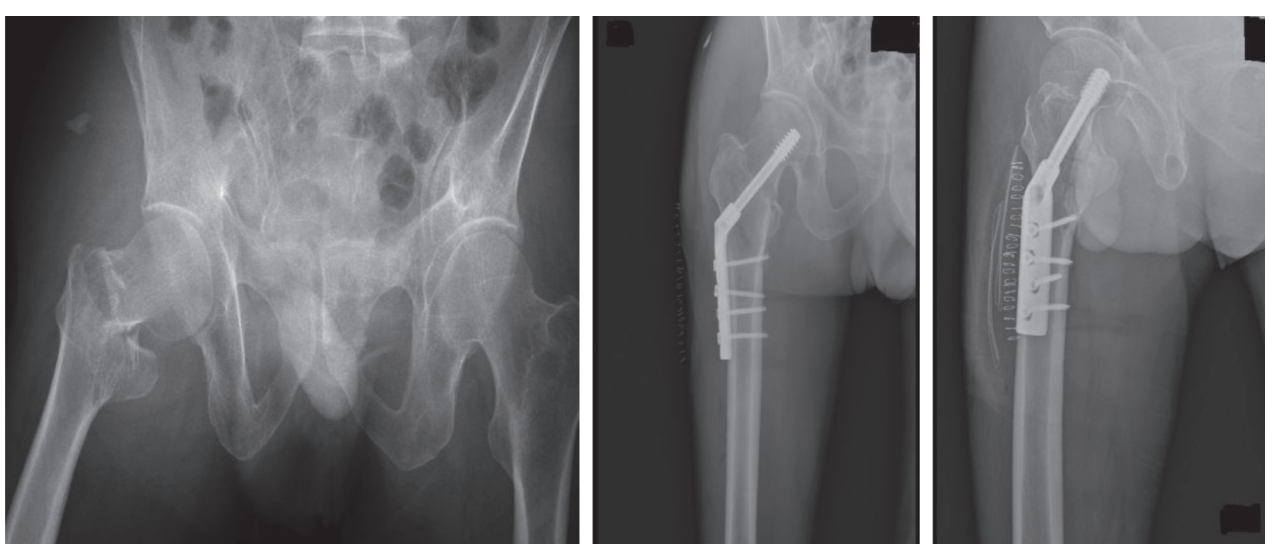

Figure 2. Pre and postoperative Rx

Postoperatively, all the patients were started on a progressive physiotherapy program. Quadriceps strenghtening exercise and hip and knee joint range of motion execises were started immediately after surgery. Full weight-bearing was allowed with the walking frame and crutches on the second day after surgery.

Results

No patients presented perioperative complications, the mean operative time was 40 minutes (range 30-55 minutes). The mean blood loss during surgery was 150 ml. No one had need to place blood drains.

All patients except one completed the physiotherapy program without any complications and returned to their normal activities. Only one patient didn't complete the physiotherapy program because had a stroke three weeks after surgery.

Discussion

Proximal femoral fractures in elderly patients represent a very significant problem in industrialized countries, due to the aging of the population.

In Italy, it is estimated that the incidence of proximal femoral fractures is approximately 90,000 per year, and that they are responsible for an annual expenditure in excess of 800 million euros in hospital costs alone. From the patient's perspective, in around 20% of cases, motor autonomy is completely lost and only 30-40% recover full autonomy in daily activities (7).

Currently, internal fixation devices for treating unstable intertrochanteric femoral fractures are clasifed into intramedullary fixation and extramedullary fixation devices, both of which show advantages and disadvantages (8-9).

The use of intra-medullary devices has increased over the years (10). There have been many reports which suggest that they do not show better outcomes than the DHS especially in AO/OTA 31A1 (A1) and A2 fractures (11-14).

The recent study of Han et al (15) confirms that intramedullary fixation device, are effective for unstable intertrochanteric femoral fractures with broken lateral walls.

The use of DHS for the treatment of unstable intertrochanteric fractures is still controversial. As DHS is the traditionally accepted treatment method in stable fractures with low failure rates (16), it's know to have a high complication rates in unstable fractures (17).

Other authors showed that DHS is a recommended implant designed for the fixation of unstable intertrochanteric fractures (18-20). The advantage of a DHS are a better exposure of fracture site (9, 20), no trauma to the medium gluteus, lower expenses compared with intramedullary nailing, lower post operative bleeding. The disadvantages are: longer incision with higher intraoperative blood loss, longer operative time; failures have been noted in unstable intertrochanteric fractures, which is primarily due to posterolateral wall fractures (21, 22).

The most common mechanical complication of DHS surgery is lag screw migration and subsequent hip screw cutout (23-25).

Conclusion

In this study, we have showed our preliminary experience with DHS in AO 31A1 fractures. AO 31A1 includes simple two-part fractures of the pertrochanteric area with A1.1 fractures along the intertrochanteric line, A1.2 fractures through the greater trochanter and A1.3 fractures below the lesser trochanter. All these are stable fractures with an intact posteromedial cortex.

From our preliminary experience is shown that MEDGAL DHS is a low cost implant easy to use for the treatment of stable pertrocanteric fractures.

Longer follow up is requiered and it will be done, to evaluete long term clinical and radiographycal results.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Preliminary experience with EBA ONE intramedullary nail for the treatment of pertrochanteric fractures

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Summary. *Background and aim of the study:* The Authors report their preliminary experience with a new fixation device for treatment of pertrochanteric fractures. The EBA ONE nail, produced by Citieffe in Bologna - Italy. *Materials:* Between April 2019 and August 2019 in Orthopedics and Traumatology Department of Piacenza, 11 patients (all female) with stable and unstable pattern of fractures, were treated with the EBA ONE intramedullary nail. *Results:* Despite the limited number of cases and the assence of a complete follow-up, the initial results are very encouraging. None of the reported complications were linked to the fixation device or to the surgical technique. *Conclusions*: The minimal, simple and intuitive instrumentation set and the simplicity of the surgical procedure make this fixation device valuable for use in stable fractures. The possibility to distal locking the nail, either statically or dynamically, and the availability of a longer nail make this device also effective in more complex fractures. (www.actabiomedica.it)

Key words: pertrochanteric fractures, Evans's classification, intramedullary nail, EBA ONE

Introduction

Fractures of the proximal femur trochanteric region are common and are associated with increased mortality and morbidity, especially in the elderly population (1-3).

Their incidence, generally occurring after a simple fall and being associated with bone fragility, increases with age (4).

Theproximal femur fracturesare divided into two large groups: the lateral and the medial ones. The medialis are so-called articular and include fractures of the head and neck of the femur and are generally treated with cannulated screws, endoprosthesis or arthroplasty based on the degree of decomposition, level, patient's age and associated comorbidities. The lateral fractures are those between the extrarticular portion of the base of the femoral neck and the transverse line tangent to the distal end of the small trochanter (pertrochanteric, intertrochanteric or subtrocanteric) and can be synthesized with intramedullary nails or, less frequently, with plaques.

Numerous classifications exist, such as that of Evans (5) which divides lateral fractures into two categories: stable (type I 2-fragment composite, type II broken down into 2 fragments) and unstable (type 3 with 3 fragments without posterolateral support, type IV a 3 fragments without medial support and type V with 4 fragments) (Fig.1) or the most recent classification AO-OTA (6) which classifies them as fractures 31-A. These fractures are divided into three groups, each of which is in turn divided into subgroups based on the obliquity of the fracture rhyme and the degree of comminution. Group 1 fractures are simple fractures with two fragments and good support in the medial cortex. Type 2 fractures they are pluriframmentary and affect the medial and dorsal cortices (small trochanter). Type 3 fractures are the oblique reverse ones,where the lateral cortex is also involved (Fig. 2).

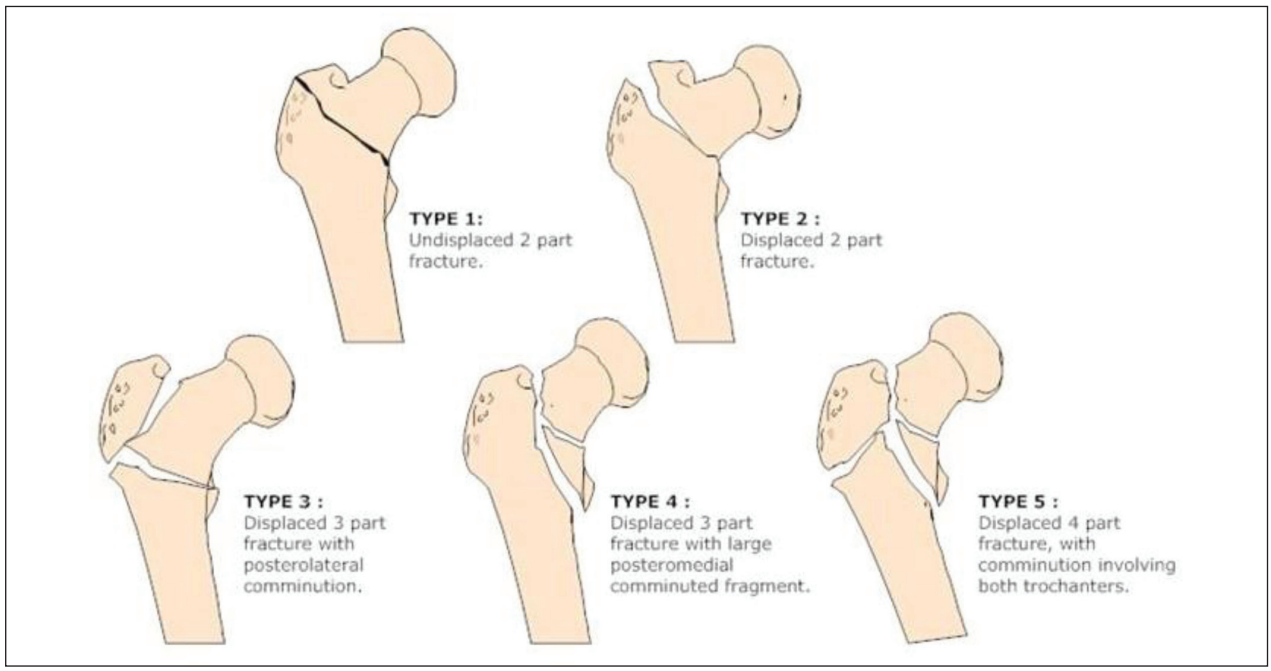

Figure 1. Evan's classification

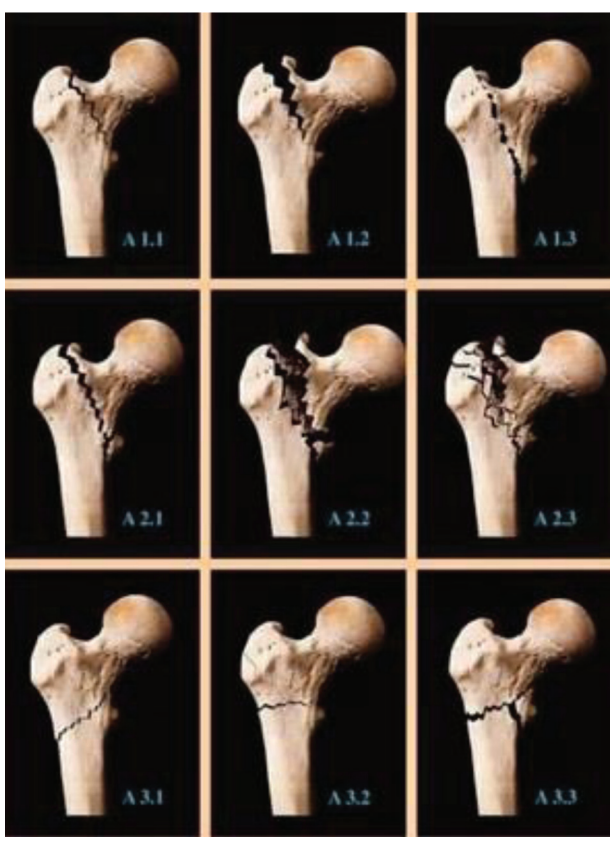

Figure 2. AO classification

Surgery is still considered as the gold standard of treatment in this elderly, frail patient cohort (7, 8), with the time to surgery parameter to be a determinant in terms of mortality rate and functional recovery (9).

A number of studies have reported improved outcomes when surgery is conducted within 48 hours from the point of admission (10, 11).

Materials and Methods

Between April 2019 and August 2019 11 patients (all female) who sustained a pertrochaneteric fracture, following accidental fall, were operated.

The mean age was 87 years (range 75-97 years).

Fractures stability was assessed according to the Evan's classification (5).

All patient were operated within 48 hours of arrival at the hospital. Prophylactic intravenus first generation cephalosporin was administred before operation and all patient received anticoagulant prophylactic therapy with molecular weight heparin.

Post-operatively, all patients had weight-bearing as tolerated and evaluated by physiotherapist the first post-operative day or when medically stable.

The EBA ONE nail is a single cephalic screw nailing system available both in the standard and long version, and is indicated for the treatment of pertrochanteric fractures, stable and unstable, intertrochanteric and subtrochanteric fractures.

The nail is cannulated for Guide-Wire controlled insertion and is made of a titanium alloy ASTM F136. The lateral surface of the stem is leveled so as to favor a balancing of the stress peaks in the middle lateral direction and allow an optimal distribution of the synthesis medium: this peculiarity facilitates the nail insertion maneuver (Fig. 3).

The proximal diameter is 15.5 mm, distal diameter is 10 mm, anti-rotational system of the integrated cephalic screw and for the standard version length 170 mm.

Three different cervico-diaphyseal angles are available (120°, 125° and 130°), to better adapt to anatomical variations of the femoral neck.

Proximally to the hole of the cephalic screw there is another hole, dedicated to the insertion of a k-wire parallel to the cephalic screw which thus allows the compaction of the fracture without the need for removal of the wire.

Figure 3. Eba One Nail

The diapason tip reduces the rigidity of the nail and the risk of perimplantation fractures under the nail.

The oblong hole allows for static or dynamic distal locking by inserting a single screw, that help pevent rotation in complex fractures.

Results

The surgical technique was the same in all patient. Operation were performed on fracture table under spinal anesthesia and image intensifier control. After close reduction of the fractures a small incision (3-4 cm) started proximal to the greater trochanteric apex was made. The entry point was made just on the tip of the greater trochanter. The nail was inserted into the femoral diaphysis without reaming. The hip screw was inserted under the midline of the femoral neck and was moved up the subarticular surface of the femoral head (Fig. 4).

Distal locking was made in 4 cases.

The mean operative time was 24 minutes (range 15-35 minutes). No one had need to place blood drains.

There were no intraoperative or immendiantly postoperative complication.

Discussion

Proximal femoral fractures in elderly patients represent a very significant problem in industrialized countries in terms of increment of hospital cost, due to the aging of the population (12).

The goal of treatment is fracture reduction and stable osteosynthesis to allow immediate mobilization. For many years, the sliding hip screw and plate had been the gold standard in treating pertrochanteric fractures (13-15). Nowadays, there is an increasing interest in intramedullary nailing, especially for the unstable pertrochanteric fractures (16).

Guidelines suggest to treat hip fractures within 48 hours of presentation and also the Ministry of Health

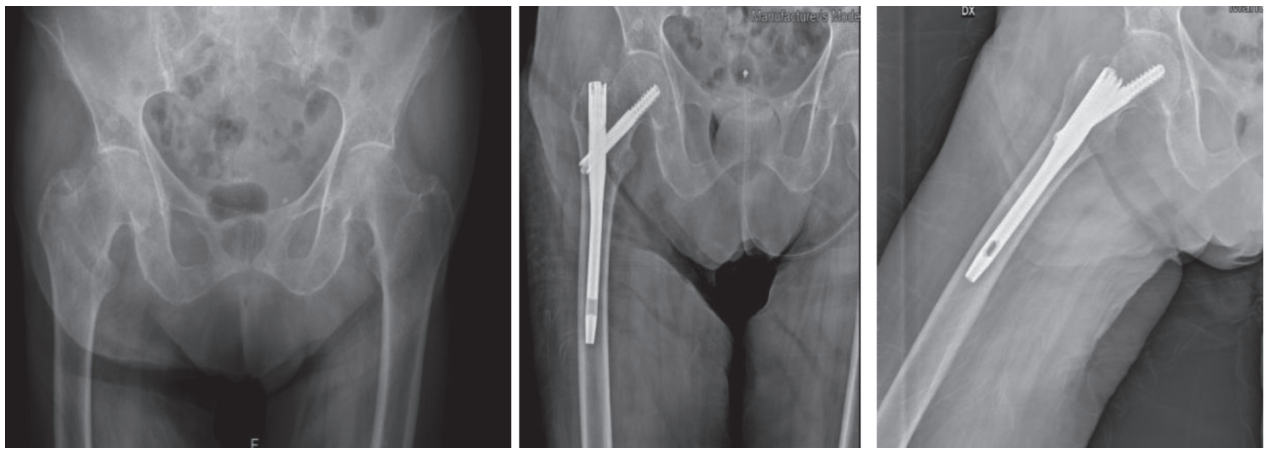

Figure 4. A 78-year-old female with right intertrochanteric fracture fixed with Eba One nail

defined quantitative and qualitative standards of hospital healthcare that establishes 60% as the minimum proportion, per surgery facility within 48 hours, of patients with femur fracture >65 years of age (12).

The choice of the correct means of synthesis and the speed in the execution of the intervention are the most important factor for the therpaeutic success.

Kaufer (17) argues that the implant's stability depends on 5 variables: bone quality, fragment geometry, reduction, implant, and implant placement. While all 5 variables are of importance, bone quality and fragment geometry are the product of the patient and the trauma and cannot be significantly modified by the treating surgeon. Reduction, implant placement, and implant selection are the variables which the surgeon can manipulate. Implant placement is probably the most important of the 5 variable.

When addressing the distal locking issue, some authors have stated that distal locking is not necessary for most intertrochanteric fracture (AO/OTA 31-A1 And A2); they then used their samples to confirm that unlocked nailing was safe and not associated with increased complications (18-20). Ciaffa et al (21), in a recent study, showed that unlocked nails were equivalent to static distal locked nails in terms of clinical outcomes, complication and healing time. On the contrary, unlocked nail were associated with a decrease in intraoperative variable such as operation and fluoroscopy time, surgical incision lenght, blood loss and also in a residual thigh pain.

The attitude at the Orthopedics and Traumatology Department of Piacenza is that distal locking is indicated only in cases of comminution of lateral wall of a greater trochanter and a large of posteromedial fragment extended distally below the lever of lesser trochanter.

Conclusion

The EBA ONE medullary nailing system is a mean comparable to those that exist on the market, such as the most famous Gamma nail.

Is designed to facilitate minimally invasve surgery and to help increase efficiency with the aid of the state-of-the-art instrumentation and an optimized surgical technique.

The initial experience with this nail was positive: there were no immediate intraoperative and postoperative complications.

The minimal, simple and intuitive instrumentation set and the simplicity of the surgical procedure make this fixation device valuable for use in stable fractures. The possibility of the distal locking, either statically or dynamically, and the availability of a longer nail make this device also effective in more complex fractures.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Pre-operative and post-operative kinematic analysis in total knee arthroplasty. A pilot study

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Summary. *Introduction:* Total knee replacement is the treatment of choice in knee osteoarthritis. Despite this, there is still a percentage of unsatisfied patients. Recently, prosthetic designs have been developed to improve the kinematics of the prosthetic knee. *Materials and methods:* Between June 2016 and November 2016 we enrolled 26 patients underwent to total knee arthroplasty divided in two groups (A and B) treated respectively with Journey 2 implant and the Attune impltant. Each patient was evaluated with functional scores (KOOS and KSS) and with kinematic analysis using the Bioval System. *Results:* In the group A, compared to the pre-operative, the flexion of the operated knees is significantly increased (31.27°±3.13° → 35.02°±2.1°) as well as that of the unoperated knee (34.34°±2.8° → 35.39°±3.5°). The pre/post-operative comparison of the muscles' activation timing showed an improvement for the unoperated side, which is closed to the physiological pattern, while the operated side showed an incorrect activation of all the investigated muscles. *Conclusions:* The Journey 2 prosthesis seems to reach better results in rotational flexion, rotational freedom and muscles activation during free walking. Furthermore, it seems that with this prosthesis the patient can feel his "new prosthetic knee" more similar and closer to the physiological one. More studies are needed to confirm these results. (www.actabiomedica.it)

Key words: knee, arthroplasty, kinematic, muscles activation

Introduction

The total knee arthroplasty is the treatment of choice in knee osteoarthritis. It has become a particularly frequent intervention, due to the increase of the average age of the people and the increase of the elderly population in our society, in fact the incidence rate of this intervention has increased from 6.3 out of 10,000 people to 11.0, with an annual rate of 5.1% (1).

The evaluation of the alignment of the prosthetic components is the subject of a great discussion: it's believed that the malposition of total knee arthroplasty is the main cause of early implant failure, as it would lead to the early appearance of knee pain and the mobilization of the prosthetic components, as well as the wear of the polyethylene insert and, therefore, at a higher rate of revision interventions. Up to 25% of patients who are subjected to knee arthroplasty have non-optimal functional results.

The alignment of the prosthetic components is generally performed along the mechanical axis of the lower limb. Several bio-mechanical studies have indeed shown that a misalignment over 3° of varus or valgus to this axis involves a change in the distribution of loads and a higher rate of prosthetic revision (2, 3). However, 98% of normal knees don't have a neutral mechanical axis and 76% have a deviation of more than 3° (4). The attempt to restore a mechanical 0° axis doesn't represent a return to normality but alters the normal kinematics of the knee (25, 26).

With this study we want to analyze the kinematics of deambulation before and after the surgery, in

order to evaluate any differences and the possible correlation to clinical disorders. The instrumental analysis of the movements allows to perform a quantitative assessment of the characteristics of posture and movement during walking or during functional activities (like taking the stairs, changing direction and running), evaluating everything with the Bioval System, concerning temporal-spatial, kinetic, kinematic and electromyographic parameters.

The arthrosis affects significantly the knee and the degenerative process involves all joint structures. The thinning of the cartilaginous layer, together with the meniscal degeneration and the formation of osteophytes, alters the mechanical congruence of the articular head and the degeneration of the ligaments alters the articular kinematics. The combination of these two elements causes the loss of the articulation's flexion-extension capacity. It has been studied the femoral rotation during flexion-extension under load in arthrosic knees: the results show a significant loss of external rotation at 20° of flexion compared to the healthy control group (1.6° vs 4.8°). The center of the femoral rotation tends to move anteriorly with the progression of the arthrosic process. These results suggest that the abnormal post-operative kinematics obtained with the traditional knee prostheses may are caused, in part, by the anatomical alterations that are already in the preoperative. Inadequate balancing of the prosthesis is the cause of the rigidity or the laxity in flexion or extension, depending on the case. It's therefore essential to perform the femoral and the tibial bone resection in respect of a correct mechanical alignment in extension and a correct femoral rotation in flexion.

With our study, we want to value the kinematic before and after total knee arthroplasty with two different implant: Journey 2 and Attune.

Journey 2 by Smith & Nephew (that has an asymmetric profile with articular rhyme at 3° of launch to the mechanical axis of the lower limb) and Attune by DePuy (that has a symmetrical profile with articular rhyme perpendicular to themechanical axis of the lower limb). Both implants are routinely used at our facility as well as internationally and are not to be considered extraordinary. At the moment, there are no direct comparative studies of the two implants.

Materials and Methods

Between June 2016 and November 2016 we enrolled 26 patients underwent to total knee arthroplasty divided in two groups. In the group A (12 patients) and group B (14 patients)

The patients have been evaluated subjectively and objectively, with the international KOOS and KSS scores, both in the preoperative and after 3 months from the surgery.

We have choosen patients with a diagnosis of gonarthrosis, requiring the placement of total arthroplasty. We decided to enrol two groups of 12 patients. Each patient was randomly assigned to group A or group B. Group A used the Journey 2 and Group B the Attune prosthetic implant. The inclusion rules were an age between 50 and 85 years, clinical and radiographic signs compatible with gonarthrosis and the presence of gonalgy and functional limitation caused by primary or secondary gonarthrosis. On the other hand, the exclusion rules were previous surgical operations on the lower limbs (including corrective osteotomies, unincompartimental prosthesis, osteosynthesis of femoral or tibial fractures, surgery at the ipsilateral ankle level), femoral or tibial fractures conservatively treated, severe pre-operative misalignment of the knee (beyond 15° in varus/valgus to the mechanical axis), very unstable knee before surgery, congenital hip dysplasia and patellofemoral misalignments.

As misurement tools we have used Bioval® inertial sensor system (Movea, France), a system with inertial sensors that allows the detection of the kinematic parameters of the body segments in the three planes of the space. This instrument consists of a software and four MotionPods with wireless sensors. Each MotionPod contains triaxial accelerometers, triaxial magnetometers and triaxial gyroscopes and is applied with adhesive tape or with elastic belts at certain points on the body without causing movement limitations to the patient. We also used Surface EMG TeleEMG®, 8-channel portable electromyograph (BTS s.p.a. Italia), then connected by means of optical fibers to the amplifiers.

The group A consisted of 12 patients, 8 females and 4 males, with an average age of 70.25 years (58-79). The group B consisted of 14 patients, 8 females

and 6 males, with an average age of 71.75 years (56-85). In Group A, 6 patients were operated on the right knee and 6 on the left one. In the Group B, 5 patients were operated on the right knee and 7 on the left one. The patients of the two groups didn't present statistically significant changes to the T-Student analysis. During follow-up, 2 patients belonging to Group B didn't make the planned three-Month post-operative check-up due to personal and health reasons. At the three-Month check-up, Group A included 12 patients and Group B 12.

Results

The pre and post-operative comparison within the group with KSS and KOOS scores values provided statistically significant results with $p<0.01$ for both Group A and B, however, a significant difference could be noted with regard to the "symptomatology" category. The direct comparison between the two groups at 3 months didn't show significant changes in terms of absolute articulation during static and kinematic tests. During the walk were recorded the data related to the angular variation on the 3 planes, relative to Flexion-Extension, intra-external rotation and abduction-adduction. The comparison has been done for each group, for the non-prosthesized side and for the prosthesized one, both in pre and post-surgery.

In the group A, compared to the pre-operative, the flexion of the operated knees is significantly increased (31.27°±3.13° → 35.02°±2.1°) as well as that of the unoperated knee (34.34°±2.8° → 35.39°±3.5°). The extension didin't show statistically significant variations, as well as the Internal rotation in the operated knee, but we saw a significant reduction in the un-operated one. The external rotation, on the other side, was unchanged in the un-operated knees and was significantly increased in the prosthetic ones. Adduction was reduced in both knees, while abduction didin't show significant changes.

In the group B, compared to the preoperative, the flexion of the operated knee was not significantly changed (35.64°±2.4° → 32.1°±4.3°) while in the unoperated knee was decreased (38.8°±3.9° → 35.9°±3.6°). The extension didn't show statistically significant variations. The internal rotation showed a significant increase in the operated knee (4.77°±2.2° → 6.62°±1.2°). The external rotation didn't have significant variations in both sides. The prosthesized side showed a significant increase both in adduction and abduction, while in the unoperated they didn't change.

The comparison between the two groups was given by the difference between the Post-operative and the Pre-operative condition of each group. In the flexion, Group A achieved a significantly greater increase compared to Group B (3.76° Vs -3.58) while the extension didn't show statistically significant differences. For the rotations we saw a significant increase for the Group A in the external rotation. In both groups there weren't significant differences for abduction and adduction (Fig. 1-2-3).

The evaluation of electromyographic was performed for each group, for the non-prosthesized side (NPS) and for the prosthesized one (PS), both in pre

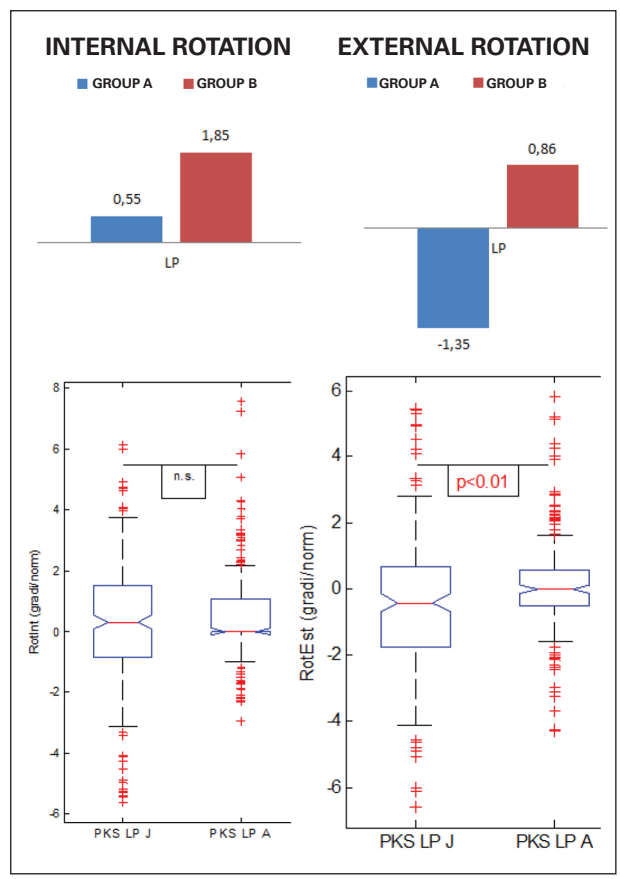

Figure 1. Comparison between Group A and B concerning internal and external rotation

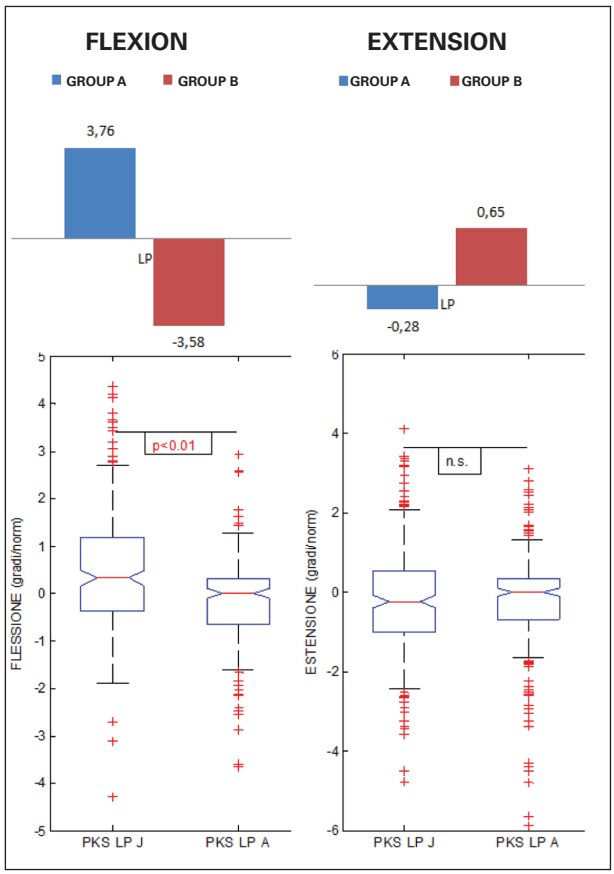

Figure 2. Comparison between Group A and B concerning flexion and extension

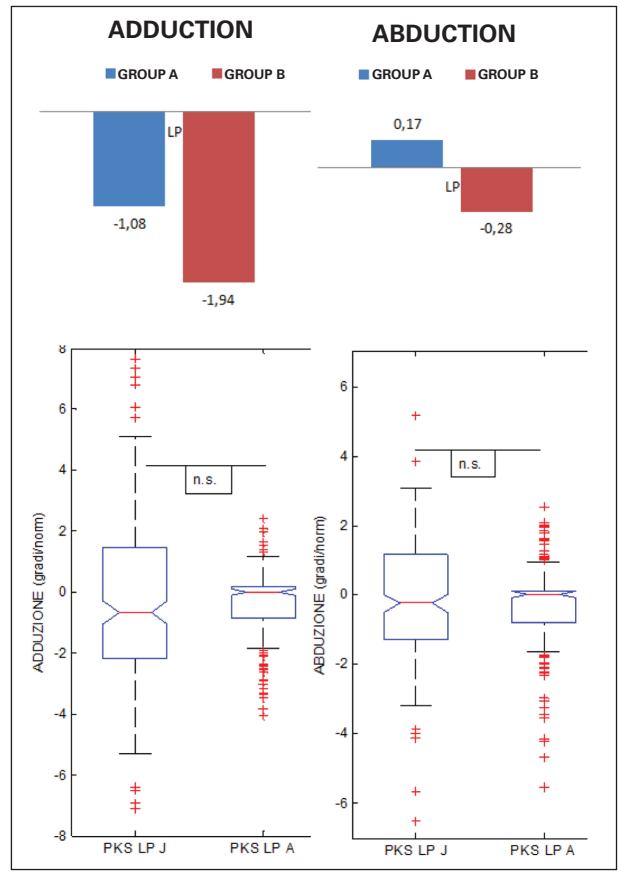

Figure 3. Comparison between Group A and B concerning abduction and adduction

and post-surgery. The analyzed muscles were: Rectus Femoris (RF), Vastus Medialis (VM), Vastus Lateralis (VL), Tibialis Anterior (TA), Semitandinosus/Semimembranosus (SEMI), Gastrocnemius Lateralis (GL).

In the group A, in the pre-operative evaluation, the knee to be operated didn't show statistically significant differences to the controlateral one. The same for the activation timing in both sides and it appeared the same as the physiological one. In the post-operative there was a general reduction for all the analyzed muscles, compared to the pre-operative condition, and that was more evident in the prothesized side. In the comparison between pre- and post-operative, there was a significant reduction for all the muscles of the prosthetic limb, especially in Rectus Femoris, Semitandinosus/Semimembranosus and Gastrocnemius Lateralis. The non-prosthetic limb has, but the Gastrocnemius Lateralis, a significant reduction for all the muscles, especially for the Quadriceps Femoris. The difference between the two sides in the postoperative period is however statistically significant for all the muscles investigated with RMS. The activation timing remains unchanged in both the conditions for both sides and is just like to the physiological one.

In the group B, in the pre-operative evaluation, the knee to be operated didn't show statistically significant differences to the controlateral one. In the side to operate was observed a prolonged activation timing for the Quadriceps and anticipated for Femoral Biceps and Semitendinosus/Semimembranosus in the last phase of the swing; there were also a tonic contraction of the Tibial Anterior and an incorrect activation of the Gastrocnemius Lateralis during swing. In the side not to be operated, there was a normal activation timing of muscles, with a slight anticipation in recruitment during the last swing phase for Rectus Femoris, Vastus Medialis,

Vastus Lateralis, Biceps Femoris and a co-contraction between Lateral Gastrocnemius and Tibialis Anterior during swing. In the post-operative there was a general reduction for all the analyzed muscles, compared to the pre-operative condition, and that more in the prothesized side. The difference between the two sides was significant for Semitendinosus/Semimembranosus, Tibial Anterior and Gastrocnemius Lateralis. The only exception was the Biceps Femoris, which showed a greater activity in the prosthetic knee. Comparing pre and post-operative, in the prosthesized side there was a significant reduction in the Rectus Femoris, Biceps Femoris, Semitendinosus/Semimembranosus, Tibialis Anterior and Gastrocnemius Lateralis. The non-prosthesized side showed a significant reduction in Vastus Medialis, Rectus Femoris, Biceps Femoris, Tibialis Anterior and Gastrocnemius Lateralis.

The pre/post-operative comparison of the muscles' activation timing showed an improvement for the unoperated side, which is closed to the physiological pattern, while the operated side showed an incorrect activation of all the investigated muscles.

In the operated side, Group A recorded a significantly a lower reduction than Group B for Biceps Femoris, Tibialis Anterior, Semitandinosus/Semimembranosus and Gastrocnemius Lateralis. ($p<0.01$). On the other side, Group B recorded a significantly lower reduction than Group A for Vastus Medialis ($p<0.01$). Concerning the unoperated side, Group A recorded a significantly lower reduction for Tibialis Anterior ($p<0.01$), while Group B for Vastus Medialis ($p<0.05$) and Biceps Femoris ($p<0.01$).

Discussion

The instrumental analysis of the movement (gait analysis) is a kind of study that has increased in the recent years, creating a great intersts among the orthopedic-rehabilitation sector (5).

In the Journey's prosthesis there is the ambitious goal of overcoming the standard prosthetic design by restoring a joint profile and with a kinematics that is similar as possible to the original one. To do this, have been made changes both to the femoral shield and to the tibial plateau. The shield is asymmetrical, with a more prominent medial condyle both distally and posteriorly, in order to restore the 3° of physiological varus. At the tibial level, the geometries follow the same philosophy. The insert seems to be more often laterally and with a slightly convex profile. Medially, it's more slim and concave. The point of the greatest concavity is in the middle third of the tibial plateau.

We have than summarized the clinical results concerning four categories: patient's satisfaction, articular ROM, articular kinematics and muscles activation valued with EMG.

In the "satisfaction" category of KSS questionnaire, out of 40 points, Group A reached 37.5 points and Group B 35.4. In the "quality of life" category of KOOS questionnaire, out of 100 points, Group A obtained 84.9 points and Group B 76.2. These results agree with the previous studies in literature (6,7). That suggests that the resolution of the knee's pain, the restoration of the physiological knee load axis and the increase of stability, due to the prosthetic are themselves enough to guarantee a good post-operative satisfaction of the patient. In our study, Journey 2 seems to be significantly better than Attune (22.75 vs 19.9, $p<0.01$).

Concerning the Articular ROM, the groups, comparing pre and post-operative results, didn't show significant differences. In the post-operative, both had a knee flexion of 108° with flexed hip, and that agrees with the literature's results (106°). In literatur it's now estabilished that post-operative ROM is directly proportional to the pre-operative articulation. A patient who, before the surgery, presents a deficit in flexion or extension will hardly recover the complete articulation (8). As far as the prostheses included in our study are concerned, the literatur shows good results: the Journey 2 has been shown to guarantee good results in terms of flexion-extension with an articular range of 0°-139° in cadaver laboratory tests (9) and, in vivo, of 0°-106° in the immediate post-operative (10) and 0°-116° after 2 years.

Also the Attune has obtained good results in the literature's studies: the design allows a gradual and soft transition from the greater curvature of the distal condyles to the smaller one of the posterior condyles. That helps to limit, although not eliminating it, the paradoxical anterior translation, giving a feling of stability (14, 15).

About articular kinematics, the differences depend mainly on the dynamic parameters recorded in the free walking. The internal Rotation increased significantly in Group B but not in Group A, while the external rotation increased in Group A and decreased in Group B: that suggests that prosthetic design may play an effective role in joint kinematics during walking, allowing Journey 2 a greater degree of rotational freedom. Compared to the pre-operative flexion, Group A recorded an average increase of about 4°, while Group B a reduction of 4°: Group A is so closer to the 55° of a physiological walk. However, in literatur there are numerous studies that don't show statistically significant differences in terms of kinematics and antero-posterior stability comparing the various models (like CR, CS and CP) (16-19). Our results sugget that prosthetic design can play an effective role in joint kinematics during walking, allowing Journey 2 a greater degree of rotational freedom.

Concerning the muscles activation valued with EMG, in direct comparison, we saw that Group A scored a lower reduction of activation in flexor muscles, Tibialis Anterior and Gastrocnemius Lateralis but, on the other hand, scored a lower decrease of the strenght for the Vastus Medialis. The activation timing was better in Group A, that was comparable to the physiological one, while in Group B all the muscles showed an anomalous timing (Fig. 4).

After implantation of a total knee prosthesis, the recovery of muscle strength is often difficult: compared to healthy subjects, the quadriceps strength decreases up to 60% in the first post-operative month and a deficit up to 30% can persist after two post-operative years (20, 21, 24). The same goes for the flexor muscles, that reuce their strength up to 50% in the immediate post-operative and a deficit up to 30% con persists after two post-operative years (21-24).

Concerning all these results, the Journey 2 prosthesis seems to guarantee a better articular synergy than the Attune prosthesis.

Our study certainly has limits, like the impossibility of kinematic sensors to evaluate rotations and translations of tibial and femoral components and even the short post-operative follow-up performed. The movement's sensors used for the recording, don't have the ability to discriminate between tibial and femoral rotation, so they indicate the rotation of the whole articulation. Than it's impossible to determinate whether pivoting is medial or lateral and to quantify the degree of femoral rollback.

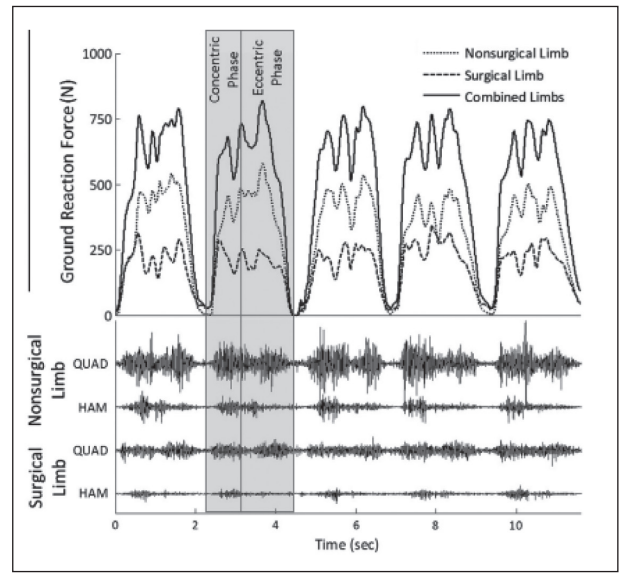

Figure 4. Ground Reaction Force and muscolar firing during 5 repeated Sit-to-Stand

Conclusions

Our study, although conduced in a short-term follow-up, showed significant results in both groups. The differences found are mainly due to the dynamic parameters recorded during the free walk in favor of the Journey 2 prosthesis. Also in the electromyography the Journey 2 prosthesis seems to guarantee better results, with a correct and physiological activation timing of most muscles and with a lower reduction for the flexor muscles. On the other hand, the Attune prosthesis allows a better preservation of quadriceps strength.

The Journey 2 prosthesis seems to reach better results in pain resolution, rotational flexion, rotational freedom and muscles activation during free walking. Furthermore, it seems that with this prosthesis the patient can feel his "new prosthetic knee" more similar and closer to the physiological one. These results can't therefore considered as definitive: a further 12 months post-operative evaluation will be necessary to confirm (or not) what we obtained.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Early experience with the ATTUNE Total Knee Replacement System

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Summary. *Background:* Modern TKA implants promise to improve functional outcomes, stability, patient satisfaction and operating room efficiency. The purpose of this retrospective study is to evaluate our short-term clinical and radiological results and survival using the ATTUNE Total Knee Replacement System. *Methods:* The authors reviewed 228 primary cemented TKAs using ATTUNE Total Knee Replacement System which were implanted between 2014 and 2018 concerning short-term clinical and radiographical outcomes and survival. Clinical evaluation was performed using the Knee injury Osteoarthritis Outcome Score (KOOS), the Oxford Score and a Numeric Rating Scale (NRS) for pain. Radiographic analysis was performed using the Modern Knee Society Score Evaluation System. *Results:* The means of the clinical results as measured with KOOS score were Pain 82,7, Symptoms 79, ADL 78,3, Sport & recreation 51,8 and QOL 78,6. The mean Oxford score was 35 and NRS 2. The mean ROM was 113,4 (SD 9,4 range 90-130). Radiographically mean mechanical axis was 1,97° of Varus and radiolucent lines were detected in 43 knees (22,4%). The survival rate is 98.4% at 2 years and 97.4% at 5 years.*Conclusion:* At short-term follow-up the ATTUNE Knee Replacement System provide excellent clinical and radiographical outcomes and good results regarding revision rate. Due to high incidence of radiolucent lines, those patients should be closely monitored even though they show no clinical evidence for loosening. (www.actabiomedica.it)

Key words: TKA, ATTUNE Total Knee Replacement, Radiolucency

Introduction

Total knee arthroplasty (TKA) is believed to be one of the most successful and effective surgical procedures for end-stage osteoarthritis with survivorship more than 94% at 16 years after surgery (1-3). However the incidence of patient dissatisfaction after TKA varies in literature and has been reported to be as high as 20% (4, 5).

There is a constant race between different healthcare companies to advance the technology employed in prostheses to further improve patient outcomes. Newer implants are regularly introduced, or design features of current implants are adjusted in an effort to achieve this (6).

In order to improve functional outcomes, stability, patient satisfaction and operating room efficiency the ATTUNE Total Knee Replacement system was launched as a modified version of a previous prosthesis (Press Fit Condylar Sigma). The theoretical advantages of this prosthesis suggested by the providers are increased conformity between the femoral component and the polyethylene insert with a gradually reducing femoral radius, an innovative s-curve design of the posteriorly stabilized cam for gradual femoral rollback and stability, an extensive range of sizes for a diverse population, optimization of the patellofemoral tracking, an improved polyethylene insert locking mechanism and incorporation of an antioxidant polyethylene insert.

However, despite such advantages, there are some design features that might cause problems.

The thickness of the patellar component is greater and hence the residual bone stock should be shallow with the increased possibility of patella fractures (7). Furthermore, the tibial component stem is located relatively posterior e this might increase the risk of injury to the posterior tibial cortex (8).

Finally recently early aseptic failures at the implant-cement interface were reported in a retrospective study based on data from Manufacter and User Facility Device Experience (MAUDE) database (9).

The purpose of this retrospective study is to evaluate our short-term clinical and radiological results and survival using the ATTUNE Total Knee Replacement System. Our primary objective is to compare our tibial aseptic loosening rate with previous reported studies. Secondly, we show our clinical and radiographic findings with those reported in literature

Material and methods

Patients

All consecutive patients who underwent TKA using ATTUNE between January 2014 and January 2018 were enrolled in this study. For all patients the indication for surgery was based on patient history and physical examination combined with anteroposterior and lateral radiography.

All TKAs were performed by 3 surgeons with certified experience in total joint arthroplasty. All implants were cemented posterior stabilized.

For all patients follow-up, sex, age at operation, revision and revision date, complications, the presence of rheumatoid arthritis, diabetes, smoking status and body mass index (BMI) were registered.

If patients were still alive at follow-up, they were invited to fill out two questionnaires and a pain score as described below.

Operative technique and rehabilitation

All operations were conducted with the patient under spinal or general anaesthesia using the same technique of medial parapatellar approach and capsulotomy with patellar eversion. Femoral and tibial bone resection were made with a modified measured resection technique.

The transepicondylar axis was used as a reference for femoral component rotation. The tibial resection was set to be 0°-3° of posterior slope in sagittal plane. The reference line for tibial rotation was accurately aimed to pass through the medial third of tibial tubercle and the second metatarsal bone. All osteophytes were removed, and any contracted medial or lateral soft tissue was carefully evaluated and selectively released when required.

The bone surface was irrigated with 0.9% saline with a pulsatile high-pressure lavage system (Pulsavac Plus, Zimmer, Warsaw, Indiana, USA) for at least 1 min. After irrigation, preparation of bone cement was initialized according to manufactures specifications. All TKA were implanted with surface cemented components using high-viscosity bone cement (Palacos, Heraeus Medical, Wehrheim, Germany). The bone cement was applied on the tibial bone surface and on the implant surface via cement gun pressurization. The tibial component was then inserted and impacted. The femoral component was inserted and impacted in the same manner. Implantation of tibial and femoral component was performed in a single step. The patella was never replaced.

Patients started with mobilization on the day after surgery dependent on pain. Normal expectancy was unaided walking after 4 weeks of rehabilitation.

Clinical and Radiographic Evaluation

Clinical evaluation at follow-up was performed using the Knee injury Osteoarthritis Outcome Score (KOOS)(10) questionnaire, an Oxford(11) questionnaire and an 11-point Numeric Rating Scale (NRS) for pain ranging from0 to 10.

The KOOS is a 42-item site specific questionnaire, resulting in five 0-100 scores (higher is better) for Pain, Symptoms, activities of daily life (ADL), Sport & Recreation and quality of life (QOL). The Oxford is a 12-item site specific score, ranging from 0 to 48 (higher is better).

The ROM was measured using a long-armed goniometer.

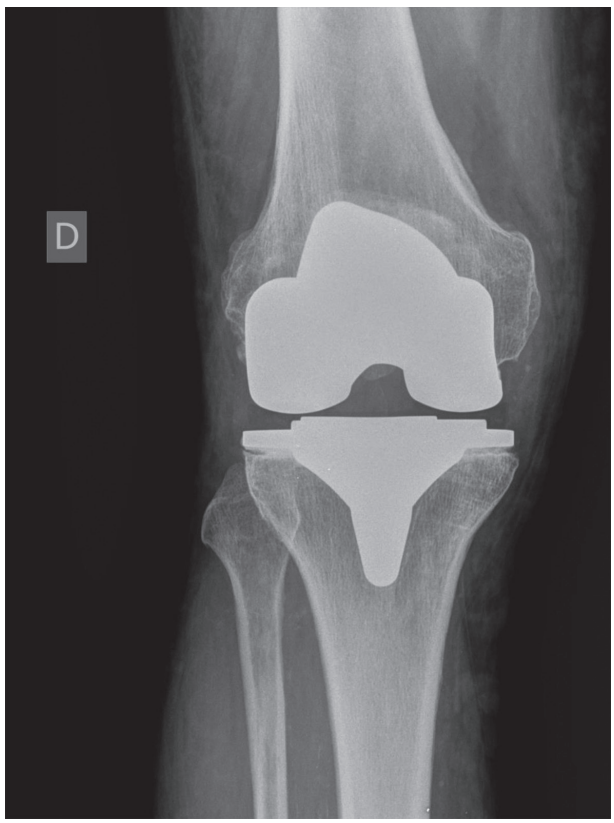

Figure 1A. Radiolucent lines (AP view)

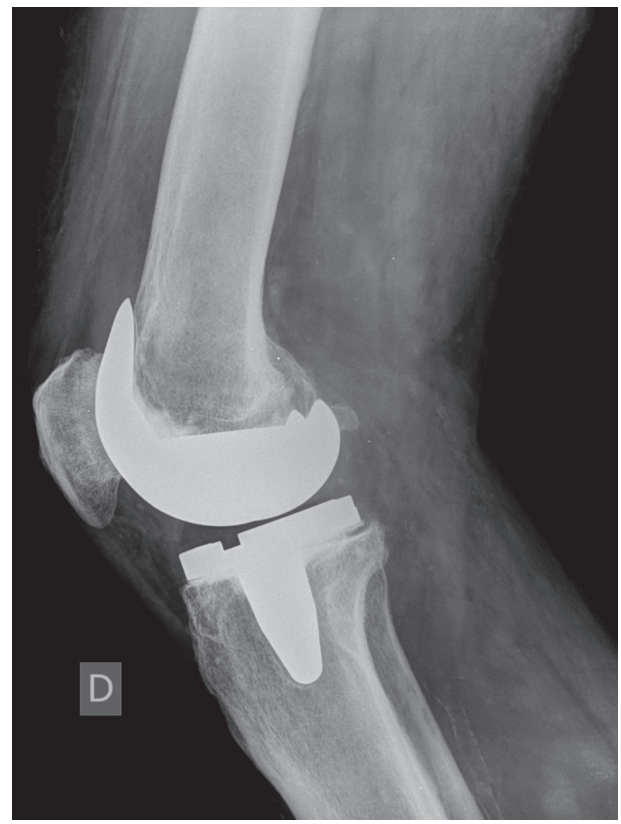

Figure 1B. Radiolucent lines (Lateral view)

Radiographic evaluation was performed with anterior-posterior (AP) and lateral x-ray of the knee joint as well as full-length standing AP-radiograph to assess correction of alignment. Detailed analyses of AP and lateral radiographs were conducted on the basis of the Modern Knee Society Radiograph Evaluation System(12) dividing each component in different zones for a standardized documentation of radiolucent lines. Radiolucencies were documented for each radiograph.

Statistical analysis

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

Results

During the period considered in the study 228 TKAs were performed with this prosthesis in 218 patients, 89 males and 129 females with a mean age of 70,3 years (SD 6,52; range 43-85).

The mean follow-up was 3,16 years (SD 1,16) ranging from 1 to 5,4 years.

Three patients were deceased at the time of the current study, 22 patients (25 TKAs) were lost to follow-up and 8 withdrew consent. A total of 185 patients and 192 TKAs remained.

The demographic data of the patients are summarized in table 1.

Clinical results

The means of the clinical results as measured with KOOS score were Pain 82,7 (SD 14,4 range 44,4-97,2), Symptoms 79 (SD 13,8 range 39,3-100) ADL 78,3 (SD 15,8 range 38,2-98,5) Sport & recreation 51,8 (SD 26,3 range 20-85) and QOL 78,6 (SD 20,9 range 31,2- 97,7). The mean Oxford score was 35 (SD 14,6 range 20-48) and NRS 2 (SD 1,7 range 1-5). The mean ROM was 113,4 (SD 9,4 range 90-130).

Table 1. Patient demography

Sex	Male: n=89 (40.8%) Female: n=129 (59.2%)
Side	Right: n=121 (53.1%) Left: n=107 (46.9%)
Age	70.3 y ± 6.52
Body height	167 cm ± 8 cm
Body weight	86 kg ± 15.2 kg
Body Mass Index	28.6 ± 3.95
Follow up	3,16 years ± 1,16 years
Smoke	Yes: n=17 (7.8%) No: n=201(92.2%)

Radiographic results

Radiographically, the mean mechanical axis was 1,97° of Varus.

Radiolucent lines were detected in 43 knees (22,4%). Table 2 display the incidence in dependence on the location of the radiolucent lines.

Complications

Revision surgery for tibial aseptic loosening was performed in 2 cases (1%), respectively 7 and 13 months after surgery, with intra operative finding of failure at tibial implant-cement interface in all cases.

Two patients (1%) developed a periprosthetic infection at 2 and 3 years after surgery respectively and were treated with implant revision in two-stage surgery.

In one patient (0,05%) patient revision surgery was performed for component malposition.

In one case (0,05%) a partial lesion of the patellar tendon during rehabilitation (confirmed with sonography) was observede(13). The patient was treated with 20 days of immobilization in an extended brace. After this period a progressive program of rehabilitation lead to a complete functional recovery.

Table 2. Summary of all radiolucent lines in the anterior-posterior (AP) tibial, lateral tibial and lateral femoral radiograph

Location, radiolucency	
Tibial AP	n=25 (13%)
Tibial Lateral	n=17 (8.8%)
Femur Lateral	n=23 (12%)

Other complications included 2 (1%) patients who developed wound infections. Both were superficial and successfully eradicated with antibiotic administration. Following surgery, 3 (1,5%) knees required one manipulation under anesthesia and 1 knee was treated with arthroscopic lysis of adhesions.

Discussion

Aseptic loosening remains a common reason for early revision also with contemporary TKA system(14, 15). Loosening in short-term analyses most likely reflects failure to gain fixation. Retrieval studies have shown that bone resorption stimulated by polyethylene wear particles and stress shielding play an important role in aseptic loosening.(16, 17). Even debonding of the tibial implant-cement interface as a result of cement type and application methods is a reported cause of aseptic loosening (15, 18).

Early aseptic loosening in ATTUNE Total Knee Replacement System is still debated.

Bonutti (9) reported high rate of early tibial aseptic failures at the implant-cement interface in a study based on data from Manufacturer and User Facility Device Experience (MAUDE) database.

In contrast, the Australian registry and the National Joint Registry of the United Kingdom (NJR) reported low rates of aseptic loosening with excellent survivorship rates (19, 20).

Even several recent studies analyzing short-term outcome of ATTUNE implant reported low revision rates (7, 8, 21-23).

In addition, Turgeon used radiostereometric analysis of the components to assess the stability of the ATTUNE prosthesis and showed secure fixation of the tibial baseplate within the first two postoperative years (24).

In this study, the revision rate for tibial aseptic loosening is 1% while overall revision rate is 2.6%. The survival rate is 98.4% at 2 years and 97.4% at 5 years.

These results are congruent with those reported in previous studies and, according to the literature, are acceptable values for primary TKA (14, 25, 26).

However, in our case series, a high number of radiolucent lines was detected at the radiographic analysis. Reasons for the high incidence of radiolucencies remain a matter of speculation.

Staats (21) reported an increased number of radiolucent lines in ATTUNE-patients than PFC Sigma-patients, especially on the tibial component. He hypothesized that it was mostly due to technique-related issues, in particular he assumed that the implant itself may allow too much movement during cement interlocking-phase. He suggested to proceed the cementation of the tibial and femoral component in two separated steps.

Another reason that can explain this high number of radiolucent lines is attributable to the design of this prosthesis, in particular in relation to the cement pockets.

In a recent study peer-reviewed digital imaging method was used to investigate cement adhesion on the ATTUNE tibial tray (27). None of the prosthesis examined in this cohort showed cement attachment at the tibial tray backside and the authors concluded that it may be related to the absence of separate cement pockets.

In the meantime, the company has launched a revised tibial component with additional cement pockets and optimized surface conditions on the tibial base that will have to be studied in the further future.

Literature about the outcome of the ATTUNE Knee Replacement System is scarce due to its recent availability.

Anyhow Ranawat (22) showed excellent clinical results in 90.7% of ATTUNE-patients after 2 years' follow up with less anterior knee pain and less crepitation than PFC Sigma-patients.

Molloy (23) reported no difference in physical function and most outcomes between ATTUNE and PFC Sigma at short-term follow-up.

Song (7, 8) in his two studies showed more favorable clinical results using the ATTUNE prosthesis than using PFC Sigma prosthesis. However, they reported ad increased risk of posterior tibial cortex injury and residual patellar injury with use of the ATTUNE prosthesis.

Additionally, Takagi (28) showed that the gradually reducing radius design of the ATTUNE prosthesis minimized paradoxical anterior slide in a navigation-based in vivo knee kinematics.

According to our findings we can confirm that this system achieves excellent outcomes at short-term follow-up.

However, the radiographic analysis of the present study doesn't allow to exclude that the tibial component may have problems even though no evidence for a higher revision rate could be detected in our study.

Conclusion

At short-term follow-up the ATTUNE Knee Replacement System provide excellent clinical and radiographical outcomes and good results regarding revision rate. Due to high incidence of radiolucent lines, those patients should be closely monitored even though they show no clinical evidence for loosening. Further studies with large cohort and long-term follow up are needed to evaluate and improve the application of this modern TKA-system.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Comparison between standard technique and image-free robotic technique in medial unicompartmental knee arthroplasty. Preliminary data

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Summary. The factors that guarantee the survival of the unicompartmental prosthesis implant seems to be linked to the accurate positioning of the components. The aim of our study is to compare the standard operative technique and the assisted navigation technique to understand if the robotic technology is able to obtain more accurate implants and with a better outcome. In the period between January 2016 and February 2018, in our Clinic, were performed 94 medial unicompartmental knee implants. The implantation of the medial unicompartmental prosthesis was performed in 30 cases with the standard technique and in 29 cases with the image-free robotic technique (Navio Surgical System). The objective of our study was to evaluate the anatomical and mechanical axes, the tibial slope, the coronal inclination of the femoral tibial space, the coronal angulation of the tibial and femoral component and the height of the Joint-Line. Furthermore, to evaluate the outcome we has execute international scores (IKDC and KSS Insall mod.). The advanced navigation seems to allow the implantation of the unicompartmental prosthesis more precisely, although not always with a statistically significant difference compared to the standard technique. further clinical studies are needed to analyze the medium and long-term survival rate, as well as the patient's subjective outcome. (www.actabiomedica.it)

Key words: knee arthroplasty, image-free robotic technique, knee

Introduction

Unicompartmental arthritis of the knee is a disease that can be tackled with different approaches, both conservative and surgical. Among the surgical approaches, we find some that act inside the articulation and others outside of it (1). The unicompartmental knee prosthesis has undeniable advantages when the right directions are followed (2). Rapid ricovery of the function, lower hospitalization, lower perioperative comorbidities, better outcomes and, not to be underestimated, lower perioperative costs (3, 4). In fact, the unicompartmental prothesis, compared to the total one, shows better results both in terms of Forgotten Knee Score and High Flexion Knee Score (5, 6).

Unfortunately, there are also some disadvantages. The most important is the higher revision rate compared to the total knee replacements. Some 30-years projections show that the revision rate is almost double (7). The works of Murray et al. and Liddle et al show that this problem is attributable to the volume of interventions. In specialized centers where are performed a large number of unicompartmental prosthesis implants, the revision rate are comparable with those of total prostheses (8, 9)

The factors that guarantee the survival of the unicompartmental prosthesis implant seems to be linked to the accurate positioning of the components. Among all, the conservation of the normal kinematics and the optimal positioning of the tibial components are protective factors against wear and potential failure of the implant (10).

These statements can give the idea that an implant positioned as accurately as possible can guarantee a better outcome, especially in the long term.

The aim of our study is to compare the standard operative technique and the assisted navigation technique to understand if the robotic technology is able to obtain more accurate implants and with a better outcome.

Materials and Methods

In the period between January 2016 and February 2018, in our Clinic, were performed 94 medial unicompartmental knee implants. The Journey UNI (S&N) prosthesis was implanted in 59 cases. Implants with Journey UNI were performed by a single experienced surgeon. The sample of 59 patients was homogeneous by sex, age (69,2 years of average) and BMI (average of 25,7).

The implantation of the medial unicompartmental prosthesis was performed in 30 cases with the standard technique and in 29 cases with the image-free robotic technique (Navio Surgical System).

To evaluate the results, the patients made a careful clinical examination in the pre-operative and 4 months after the surgery, and they made radiographic investigations in the pre-operative and in the post-operative after 4 months, morover they compiled some international scores (IKDC and KSS Insall mod.) both in pre and post-operative period. In particular, for the clinical examination were evaluated flexion, extension and the pain. For instrumental examinations were performed x-rays in antero-posterior projection under load, lateral projection, axial projection at 45° for patella, Kneeling View and pangonogram of lower limbs.

The objective was to evaluate the anatomical and mechanical axes, the tibial slope, the coronal inclination of the femoral tibial space, the coronal angulation of the tibial and femoral component and the height of the Joint-Line. Radiographic investigations and measurements were performed by a single radiologist.

Results

The results of the post-operative assessment showed a good recovery of flexion and extension in both groups of patients: in the group subjected to intervention with the standard technique there was a deficit of extension always <5° and an average flexion of 118°. In the Navio group, the results were similar: the extension was always excellent (deficit always <5°) and an average flexion of 127°, slightly better than the standard technique.

Also the evaluation of pain is comparable in the two groups: according to the NRS scale, the average pain recorded in the Standard group is 2,3, while in the Navio group is 1,9. The results of the scores given to the patients show good results. In the Standard group, IKDC before and after surgery were respectively 74,7 and 87,0, while in the Navio group they were 74,3 and 89,9 respectively. We have to say that the best result of the Navio group (+2,9) isn't statistically significant. Concerning the KSS score, the trend was similar: in the Standard group the pre- and post-operative evaluation gave respectively 58,9 and 81,1, while for the Navio group respectively 58,6 and 83,2. Also for the KSS there was a better result in the Navio group (+2,1), that is still not statistically significant.

In the pre- and post-operative pangonogram was evaluated the possible variation of the anatomical axis: in both groups there was never a variation greater than 5°. In the Standard group the variance from the anatomical axis recorded in the pre-operative was ±2.1°. In the Navio group the variance recorded was lower, ±1.3°. These results have no statistical value. Also the radiographic evaluation of the tibial slope and the height of the Joint Line showed similar results: the variance recorded from the pre to post-operative for the tibial slope is ± 3.1° in the Standard group and ±1,7° in the Navio group. Concerning the Joint Line, was found a variance with the pre-operative in the Standard group of ±1,7 mm and in the Navio group of ±1.1 mm. The values also have no statistical significance.

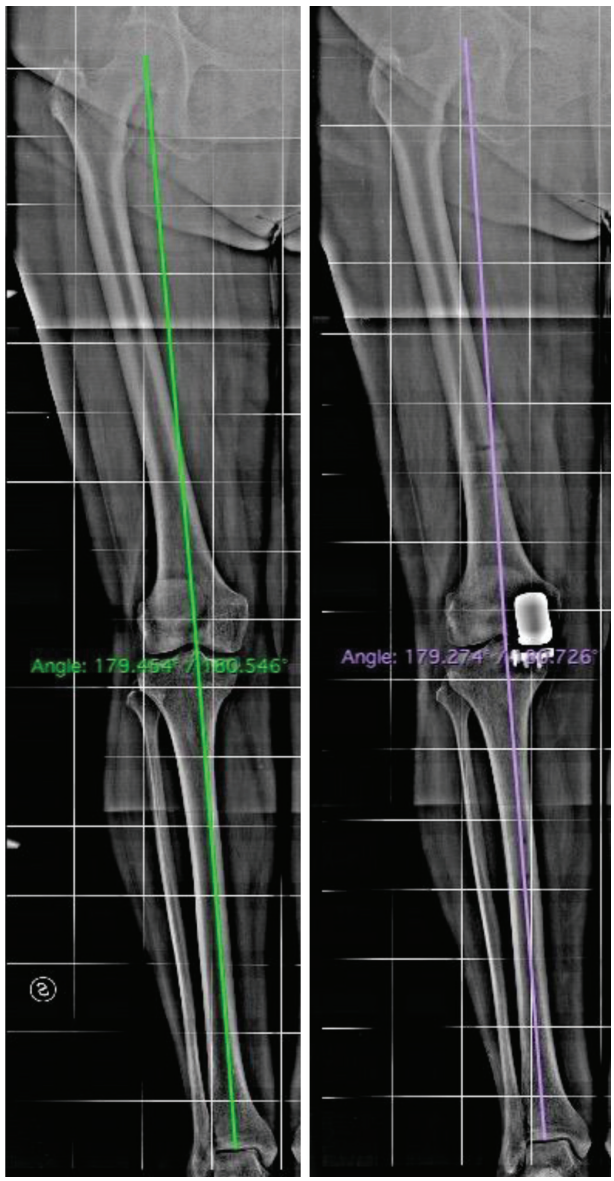

Figure 1. Pangonogram pre- and post-operative

Discussion

In literature there is a lot of interest about this topic: in fact, there are numerous studies that analyze the advantages of robotic surgery in orthopedics. In a review by Lonner et al are analyzed some of the most widespread robotic technologies for orthopedic (11). However, there are few studies concerning advanced image-free navigation and for the most they concern studies on dead bodies (12) and synthetic bone (13). Only a few studies analyze retrospectively clinical data and the results show always greater accuracy in the positioning of prosthetic components: for example, in the work by Harry et al, the height of the Joint Line is taken into consideration as a parameter (14).

Ours is certainly a preliminary work and the results presented must by analyzed in a more detailed way. But it's based on clinical results and on measurements taken without the aid of the navigation system itself, and therefore independently performed. That allows us to evaluate the result and the accuracy of the system in guiding us in the positioning that we have previously planned. The overall results obtained by adding the two groups allow us to affirm that in both cases the implantation of the unicompartmental prothesis is effective in terms of subjective and radiographic outcomes. The results are therefore aligned with the literature and allow patients to improve their initial conditions (6).

However, it must be emphasized that the study has important critical points. First of all, the number of the sample is very limited, mainly due to two reasons: in addition to the small number of patients enrolled, the volume of interventions and the possibility of access to this technology were certainly a problem. Currently, the accessibility to this technology is easier, so our work will continue and will probably have greater scientific weight. Also, in all the assessments made there is a minimal superiority of the results obtained with the computer-assisted procedure Navio Surgical System, although never statistically significant: that agrees with numerous articles in literature (13-16).

Our technology is image-free and therefore doesn't require the pre-operative processing of data from CT radiographic investigations, such as some system on the market. That can certainly be considered an advantage as there is less exposure to ionizing radiation from the patient. The image-free system don't have the risk of working on wrong or modified data, because they are recorded at the same time as the surgery. On the other hand, with systems that require CT investigations, there is a risk that the information collected with the radiological investigation has changed at the time of the surgery, if there is a significant period of time between the two moments.

Another advantage of the Navio advanced navigation system is that it allows the surgeon to assess

and quantify the tension of the soft tissues in real time, by simulating different scenarios, depending on the virtual positioning of the prosthetic components (12). Before making the cuts with the aid of the robotic cutter, it's possible to verify, thanks to previously collected data, the real dimensions of the implant and its dynamic behavior, the articular kinematics as well as the variation of the contact points of the components, depending on the degree of flexion.

These advantages and the absolutely preliminary results allow us to affirm that, despite the limited number of our sample and the short-term follow-up, the Navio system has shown a greater accuracy in the positioning of the prosthetic components (13, 15, 16).

Conclusions

The advanced navigation or image-free robotic technique seems to allow the implantation of the unicompartmental prosthesis more precisely, although not always with a statistically significant difference compared to the standard technique. Surely, this is a safe procedure for the patient and is simple for the surgeon. However, further clinical studies are needed to analyze the medium and long-term survival rate, as well as the patient's subjective outcome.

The simplicity of the procedure may suggest that it's also suitable for young orthopedic surgeons, but probably is not so (17). This technology certainly has the capacity to be didactic, but it must be used by those who completely dominate the standard technique. The possible switch to the traditional technique may be necessary to take on with some intraoperative complications or even with the instrumentation itself.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

ACL reconstruction using a bone patellar tendon bone (BPTB) allograft or a hamstring tendon autograft (GST): a single-center comparative study

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Summary. *Background and aim of the work:* There is still debate on which graft is better indicated for anterior cruciate ligament (ACL) surgical reconstruction. The objective of this study was to evaluate the medium-term clinical outcomes of ACL reconstruction comparing patients managed with bone patellar tendon bone allograft (BPTB) versus patients treated with hamstring autograft (GST). *Methods:* Patients enrolled during the period 2013-2016 underwent a personal interview with the use of specific evaluation questionnaires (Tegner e Lyshom, Knee Injury and Osteoarthritis Outcome Score, International Knee Documentation Committee), a clinical evaluation with the use of objective functional tests (Lachman test, pivot-shift) and a physical examination of the knee. *Results:* In this study 43 patients were enrolled: 21 patients were treated by autograft and 22 patients by allograft. Patients who received allograft ACL reconstruction returned to normal sport activity earlier than patients operated on using autograft (11.7±10.3 vs 17.9±14.6 weeks, $p<0.05$). Data obtained with subjective tests, clinical and physical examination were positive overall, with no differences observed between the two groups. Finally, 15 allograft patients and 12 autograft patients accepted to perform the proprioceptive tests: no difference was found between the two groups. *Conclusions:* At follow-up evaluation after ACL reconstruction, both BPTB allograft and GST autograft patient groups showed similar results at subjective, objective clinical evaluation and proprioceptive properties of the limb. In particular, the use of allogenic BPTB allowed the patients to return earlier to normal activities of daily-living and sport activity. (www.actabiomedica.it)

Key words: ACL reconstruction, BPTB allograft, GST autograft, limb proprioceptive properties

Introduction

The Anterior Cruciate Ligament (ACL) is a key structure in the knee, acting as the primary restraint to anterior tibia displacement (1). Although ACL tears are common in orthopedic clinical practice (1), the optimal treatment for ACL tears remains controversial (1-3). Nowadays, there is still a debate on which type of graft is the most ideal ACL reconstruction. Three types of graft have been described: biological autograft, allograft and synthetic grafts (4). At the present time, synthetic grafts are less utilized, because most of orthopedic surgeons prefer hamstring autograft tendons or the patellar allograft tendon for anterior cruciate ligament reconstruction (ACLR) (4). In fact, the recent literature has suggested the use of biological autografts, especially in young patients, due to their potential for remodeling, tendon to bone healing and the advances they present when compared with allografts (5). Among the available graft options, hamstring ten-

don autografts with doubled semitendinosus tendon and gracilis tendon have become the most commonly used type for ACL reconstruction (6).

The comparison of clinical outcomes reported by allograft tissue vs autograft have led to contradictory results, with some case series reporting no differences in outcomes and others reporting an increased risk of failure (7-10). A systematic review showed no significant differences in graft failure rate, postoperative laxity or patient-reported outcome scores when comparing ACLR with autografts and non-irradiated allografts (11). Some authors reviewing the literature have underlined that bone patellar tendon bone (BPTB) allograft tissue used for ACLR presents a higher risk compared with surgery performed with a BPTB autograft (8). The differences between outcomes of allograft ACLR may be dependent on the fact that there are numerous protocols of processing and preparation (12, 13). The influence of these protocols on the allograft tissue is still to be defined. While some authors found that non-processed allografts and those irradiated with <1.8 Mrad, with or without chemical processing, did not have a different risk of revision compared with hamstring autografts after 2.5 years; others argued that these processes led to a different risk of revision (1).

In addition, anatomical and age factors may influence the outcome of ACLR. Lansdown et al. demonstrated that load to failure and graft stiffness varied across different tissue types. Regional differences were noted in patellar tendon grafts, with the central third showing the highest load to failure and stiffness. Graft diameter and donor age (older than 40 years, and especially older than 65 years), negatively impacted biomechanical properties, whereas gender had only a minimal effect (14).

Several studies that compared the outcome of autografts and allografts have failed to reach a conclusion as to which is the better, possibly because of different fixation materials and non-prospective study designs (15-21). In this contradictory context, the aim of the present study was to evaluate and compare the clinical outcomes and the results of subjective and proprioceptive tests of a series of patients who underwent ACLR with fresh-frozen bone patellar tendon bone allograft (BPTB) and ACLR with hamstring autograft (GST).

Material and Methods

Patients

From January 2013 to January 2016, a consecutive series of patients diagnosed with acute ACL ruptures underwent ACLR at our Level I healthcare trauma centre. All subjects participating in this study received a thorough explanation of the risks and benefits of inclusion and gave their oral and written informed consent to publish the data. The study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki as revised in 2000 and those of Good Clinical Practice (22).

Patient Selection

The inclusion criteria were instability due to ACL deficiency, with or without meniscal injury, treated by primary unilateral reconstructions of the ACL. All patients considered in this study had to be between 18 and 43 years of age and give their informed consent to participate. Exclusion criteria were as follows: patients with posterior cruciate ligament (PCL) injury or collateral ligament injury at the time of surgery, acute or chronic injuries in the same or contralateral leg, chondral injury of grade 2 or higher evaluated according to the Outerbridge classification system (23), degenerative joint disease of grade 2 or higher according to Kellgren-Lawrence score (24), and metabolic bone disease. All patients had a preoperative magnetic resonance imaging scan to exclude combined, complicated ligament injuries to their knees.

Surgical Technique

All patients underwent an intraoperative clinical examination under anaesthesia, followed by a diagnostic arthroscopy to confirm the preoperative diagnosis and to evaluate other intra-articular injuries (Figure 1). All ACLR procedures were performed by the same senior arthroscopic surgeon using a trans-tibial approach. In all operations, plexus anaesthesia was performed consisting in a regional block, which involved both sciatic and femoral nerves (bi-block), while sedation was used when necessary. Prophylactic cefazolin

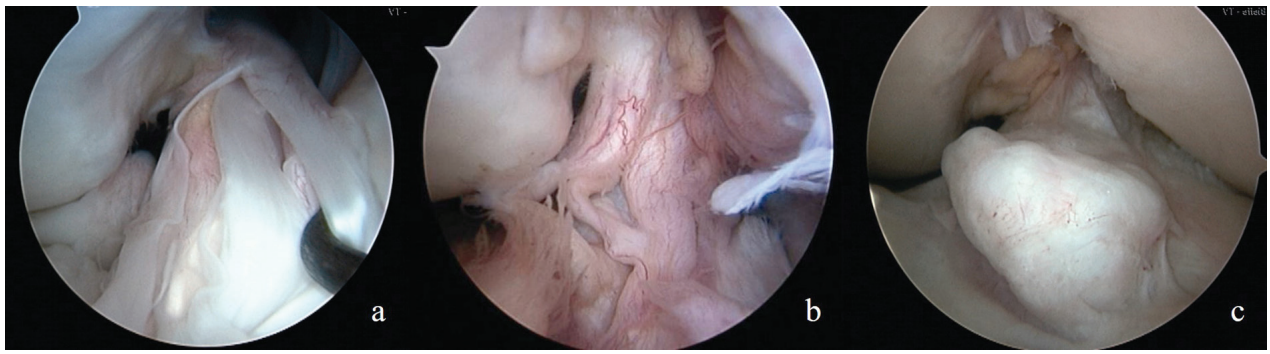

Figure 1. a-b-c. Different arthroscopic evaluations of ACL injuries

(2 g) was administered and continued 24 hours after surgery. Postoperative antithrombotic therapy (Natrium Enoxaparin) was given until full weight bearing was achieved. The patient was placed supine on an operating table; a thigh tourniquet was always applied.

At our I-level trauma centre the allografts are isolated from a whole BPTB received from the Musculoskeletal Tissue Bank (Treviso Tissue Bank Foundation). On the day of the operation, the graft was thawed in sterile physiologic solution at room temperature before preparation and then preconditioned using the graftmaster board at 20 lb of tension for 20 minutes (Figure 2). The autografts were prepared following the same protocol used for allografts. The autologous gracilis and semitendinosus tendons were harvested through an oblique 3 cm incision over the pes anserinus (Figure 3) using a tendon stripper (Arthrex, Naples, FL) with the patient positioned on the operat-

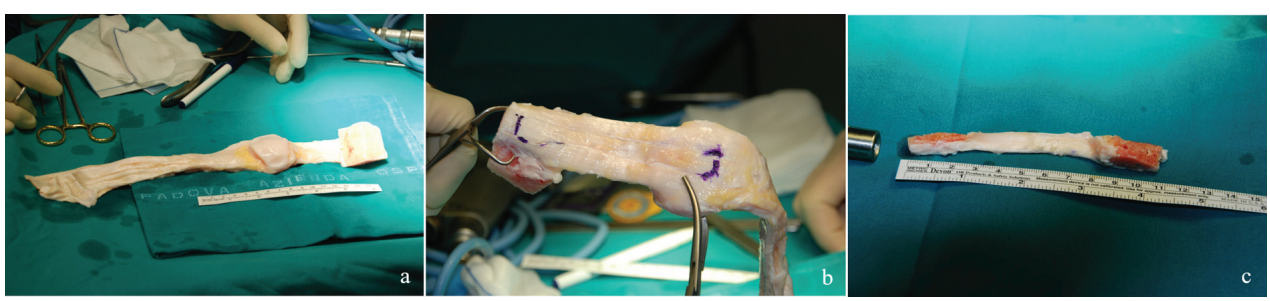

Figure 2. Three stages of allograft tendon preparation. a) BPTP at the initial stage, after thawing and preconditioning on the graft master; b) the part of BPTP choose for ACL substitution is measured and the bone part is shaped with an oscillating saw; c) allograft ready for implantation

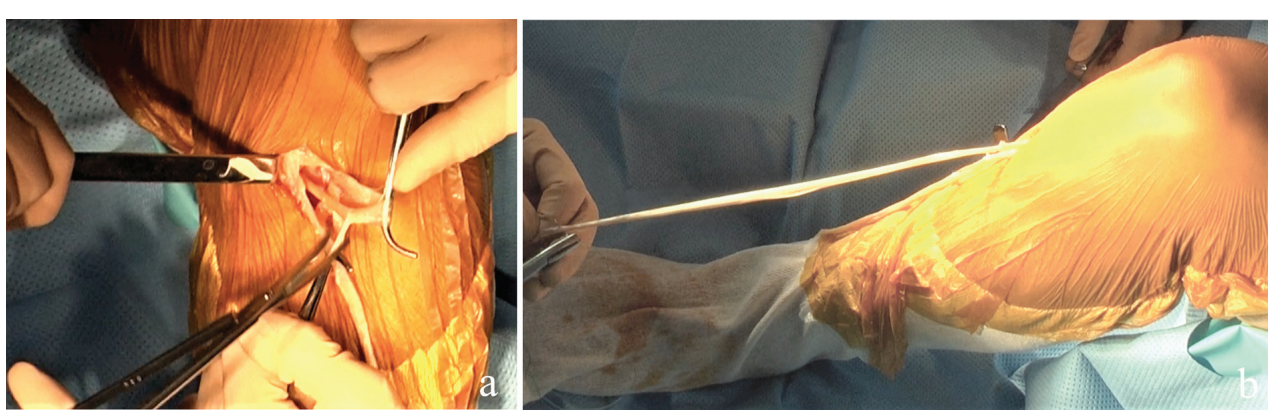

Figure 3. a-b. Gracilis-semitendinous autograft harvesting

ing table with his knee maintained at 90° flexion using a knee post that allowed complete flexion if needed. On a Graftmaster board (Arthrex), the tendons were cleaned from soft tissues and their taper parts were cut off. Both tendons were sutured together to form a 4-strand graft and looped over 1 single EndoButton (Smith & Nephew Endoscopy, Andover, MA). The distal free ends of the tendons were armed with No. 6 Ethibond sutures by a whipstitch technique, and the grafts were pre-tensioned under 20 lb for 20 minutes and made ready for the passage through the bone tunnels. The graft has been always shaped to obtain a 9mm diameter. For both graft types, tibial and femoral tunnels were drilled according to the precise diameter of the graft with the same technique; the tibial tunnel was first prepared in standard fashion. The tibial attachments of the remnants of the native ACL were preserved as much as possible to serve as a landmark for tibial guide pin placement. A 9 mm tunnel was then drilled at 55° from the tibial axis. The femoral tunnel was performed through the tibial tunnel following the classic technique reaching 3 cm depth. The graft was passed following the sutures through the tibial tunnel, along the joint, in the femur and through its lateral cortical bone. When correctly positioned, the graft was fixed using the De Puy-Mitek Rigid Fix system with polylactic 2.7 mm resorbable pins. After proximal fixation, 10 flection-extension join cycles were performed in all patients in order to pre-stretch the graft that was then fixed in the tibial tunnel with the knee flexed at 20° with a reverse anterior drawer manoeuvre under maximal manual tension. In both groups the fixation was performed using an interference screw (Smith and Nephew Endoscopy, Andover, MA, USA) with the same diameter of the tunnel.

Rehabilitation protocol

After ACLR, all patients followed a standardized postoperative rehabilitation protocol, which emphasized early restoration of full extension and strengthening exercises for the quadriceps; a brace allowing full range of motion and was used.

Full weight bearing using crutches and mobilization of the knee using a brace were allowed from the first day after surgery and during the first 15 postoperative days with flexion exercises beginning from 45° with a daily increase of 10°, not going beyond 120° during the first 4 weeks. Exercises to regain proprioceptive abilities were suggested starting 8 weeks after surgery. Swimming, cycling and running were allowed from the 12th week. Full return to the sport activity performed before the injury was planned 6 months after surgery.

Patient assessment

All patients underwent evaluation by history, physical examination, questionnaires and proprioceptive assessment at a minimum follow-up of 24 months. Data collection was retrospectively performed at our institution by two external and independent investigators, not involved in the patients' treatment and blinded to the graft being used for each patient.

The objective clinical examination included: testing knee laxity, the Lachman test, pivot-shift test, varus/valgus stress test, presence of effusion and range of motion (ROM) of the knee. Subjective clinical outcome was evaluated at the follow-up by the Knee Injury and Osteoarthritis Outcome Score (KOOS) (25), International Knee Documentation Committee (IKDC) (26), Tegner activity score and modified Lysholm knee scoring scale (27, 28). The Lachman, pivot-shift and varus/valgus stress tests were used before surgery and at final follow-up. KOOS, IKDC and Tegner activity score and the modified Lysholm knee score were used to evaluate knee function.

Evaluation of proprioceptive and balance ability was performed by the Pro-Kin Type B line system (Techno-Body TM) that evaluate the postural stability in a static or dynamic double or single-leg situation. The platform stability is provided via an electro-hydraulic system driven by two stepper motors. Furthermore, it allows upper body and lower body movements to be differentiated by assessing the variation of the trunk position using an angle inclination measure fixed on the sternum of the individual. Finally, the patients were divided into two groups: group I (patients who underwent to ACLR using BPTB allograft) and group II (patients who underwent to ACLR using GST autograft) and outcomes were compared between the two groups.

Statistical analysis

Continuous data were checked for a normal distribution using the Shapiro-Wilk test. Continuous variables were reported as mean±standard deviation. The outcomes of the continuous variables (IKDC, KOOS, Lysholm and Tegner Score, Fisioterapy and timing of sport return) were compared between the 2 groups using the Mann-Whitney U test. Categorical variables (recurvate and extension) were compared with the χ^2 test. The Lachman test, Pivot-shift test, varus/valgus stress test and presence of effusion were evaluated by Fisher's exact test. Proprioceptive sensitivity was evaluated in both groups looking at the differences between the operated limbs or comparing in each subject the proprioceptive properties of the repaired limb versus the contralateral healthy one. The data obtained were analysed and statistical difference was evaluated using the non-parametric Wilcoxon signed rank test. Statistical significance was defined as $p \leq 0.05$. All statistical analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC, USA) for Windows.

Results

During a 3-year period, 71 patients with an ACL rupture were treated at our institution. It was not possible to evaluate 28 patients because 11 refused to participate for lack of interest, 2 had PCL injuries, 1 had an external collateral ligament injury, 3 had a contralateral ACLR, and 4 patients presenting cartilage lesions higher than II grade of Outerbridge at the time of surgery and a follow-up address could not be retrieved for 9 people. Hence, 43 patients (41 men and 2 women) were retrospectively enrolled in the present study. All patients underwent clinical assessment at the final follow-up, while twenty-seven patients accepted the stabilometric and proprioceptive assessment. Twenty-two patients underwent ACLR with BPTB allograft (group I) and twenty-one underwent GST autograft (group II). The average follow-up period was 44.8±20.4 months. The mean age of the patient cohort at the time of injury was 31.5±11.9; it was similar for group I (31.9±12.5) and for group II (31.0±11.7) (p=0.84). There were 13 right knees and 9 left knees in group I, 14 right and 7 in group II. No differences were observed regarding body mass index (BMI), recurvatum or valgus deformity between the two groups. No statistical differences between the two groups were reported as regard the durations of physical therapy: 9.5±4.2 months for allograft and 10.5±10.4 months for autograft (p=0.40).

The mean IKDC score was normal or nearly normal in both groups, 94.5±5.8 for group I and 94.4±9.3 for group II (p=0.31) (Table 1). Analyzing KOOS scores, group I reported a mean score of 89.4, while the group II mean score was 90.1 (p=0.40). Similarly, there was no statistical difference in Lysholm scores between patients in group I (96.4±5.0) and patients in group II (96.0±7.2) (p=0.99). As regard the return to sports practice (running, cycling or swimming), there was a statistical difference (p=0.049) in favor of group I: mean 11.7±10.3 months vs 17.9±14.6 months for

Table 1. Clinical outcomes of the cohort

Variable	Overall Patients (N=43)	Group I (N=22)	Group II (N=21)	p-value
IKDC (Mean ± SD)	94.5 ± 7.6	94.5 ± 5.8	94.4 ± 9.3	0.31
KOOS (Mean ± SD)	94.4 ± 8.8	93.9 ± 8.5	94.89 ± 9.26	0.40
Lysholm Score (Mean ± SD)	96.2 ± 6.1	96.4 ± 5.0	96.0 ± 7.2	0.99
Tegner Score pre (Mean ± SD)	6.5 ± 1.3	6.6 ± 1.3	6.3 ± 1.2	0.21
Tegner Score post (Mean ± SD)	5.8 ± 1.3	5.9 ± 1.2	5.8 ± 1.4	0.71
Return to sport (months, Mean ± SD)	14.8 ± 12.5	11.7 ± 10.3	17.9 ± 14.6	0.049
Return to work (months, Mean ± SD)	3.65 ± 3	3 ± 2.5	4.3 ± 3.5	0.049

SD = standard deviation.

the group II. Group I return to work earlier (mean 3±2.5 months) compared to group II (mean 4.3±3.5 months) (p=0.049). A reduction of the activity level was recorded in both groups of patients using the Tegner score. The mean Tegner score (of all patients) was 6.5±1.3 before ACL injury and 5.8±1.3 at the follow-up. In particular, the mean Tegner score for patients who underwent ACLR with BPTB allograft was 6.6±1.3 before injury and 5.9±1.2 at the follow-up and for the patients with GST autograft was 6.3±1.2 and 5.8±1.4, respectively. No statistical differences were reported among the two groups before and post injury (p=0.21 and p=0.71, respectively).

Data collected by physical examination showed no significant difference in outcomes between the two groups. In fact, the Lachman test was negative in 90.9% of group I patients and in 81% of patients of group II; the pivot shift test was negative for 100% of patients in group I and 90.5% in group II (p>0.05). There were also no significant differences between BPTB allograft and GST autograft groups in the percentage of patients with a knee stiff or swollen, or in the percentage with positive tests for meniscal tear.

Post-operative ROM was almost complete for both the two groups, in particular 21 (95.5%) patients for group I and 18 (85.7%) patients for group II could reach the full flexion (135°) and all 43 patients gained full extension of the knee. As regards the stability and proprioceptive scores no statistical difference were observed in the results of stabilometric bipodalic (with eyes open or closed) and monopodalic tests between the two groups. Patients of all groups obtained similar scores in the measures of center of pressure excursion for the operated knee and the contralateral one. In the dynamic tests there were no differences between the scores of group I and group II and with the scores reported for the contralateral non injured knee. The score of all index were comparable with the score reported by Techno-BodyTM for athletic subjects.

In particular:

- the mean bipodalic stability index was 1.2±0.5, group I 1.1±0.4 and group II 1.3±0.6 (p=0.49)
- the mean monopodalic stability index was 1.6±0.7, group I 1.5±0.6 and group II 1.8±0.7. (p=0.32). The mean scores of contralateral one was 1.8±1.0
- for the average track error (ATE) index, which evaluate the proprioception, the mean results for all 43 patients were 33.3±12.7 for the operated knee and 38.2±13.6 for the contralateral one. No statistical difference was found between group I (35.4±15.6) and group II (30.7±7.9) (p=0.51).

No major complications occurred and there were no reoperations. No cases of infection, fibrosis or deep vein thrombosis were recorded.

Discussion

Although comparative studies on the uses of autografts and allografts for ACLR have shown similar clinical and radiological outcomes (17-21, 29-32), most were conducted using patellar or Achilles tendons (17-19, 21, 29). In this study, we compared ACLR using BPTP allograft and GST autograft with a minimum 2-year follow-up. Our data demonstrated that there are no statistical differences in clinical outcomes and in the results of patient-oriented tests between subjects who underwent ACLR with BPTB allograft or GST autograft. Further, the outcomes were satisfactory and no complications or re-ruptures were recorded. Moreover, we did not find statistical differences in clinical, proprioceptive and stabilometric outcomes between the two groups of patients.

Comparing the clinical outcomes between the two groups, we did not observe statistical differences in anterior laxity or rate of graft rupture, according to the anterior drawer test (ADT) and the Lachman test. Further, the rate of rotational instability was not increased according to the pivot-shift test. Analyzing ROM measurements, no loss of extension was found between two groups and 39 (90.7%) patients reach 135° of flexion. Overall, good and excellent results at the clinical assessments for BPTB allograft and GST autograft are in line with the results reported in the literature (33-35). According to these studies, autograft does not provide better clinical outcomes than allograft. Subjective tests evaluating the knee functionality (IKDC, KOOS, Tegner activity score and Lysholm knee scoring scale) returned mean scores nearly close to normality. No difference between the two groups was found.

Sun et al. found no significant difference between autograft and BPTB allograft in their IKDC scores (32). They reported that 93 % of autograft and 91 % of BPTB allograft groups showed normal or near normal activity at the final follow-up (32). This study results of IKDC score was comparable to their results.

Analyzing the return to sport, we found a reduced number of patients that return to a regular previous sport activity, although the difference in Tegner scores before injury and at final follow-up after surgery was not statistically significant for both groups. Similar results were reported in a recent study by Legnani et al. (36). We found a difference between two groups evaluating the timing to return to work. The members of group I returned to work earlier than those of group II. This finding may depend on the lower level of pain experienced in the first post-operative period by patients with BPTB allograft, which avoid donor site morbidity. Other possible confounding factors evidenced by the literature (37), such as work placing a high demand on the knees or the period suggested to patients for using crutches, were comparable between the two groups.

Young et al. evaluated the mechanoreceptor reinnervation of autografts and allografts after ACLR (38). Histological examination showed significantly less neurofilament P (NFP)+ neural analogs both in allograft and autograft patients compared to healthy control tissue, but no differences were highlighted between the two graft groups (38). It was hypothesized that the loss of proprioceptive function occurred after ACL rupture may be due to deficit of reinnervation (38).

In our study both grafts showed similar proprioceptive and stabilometric performances. Moreover, we did not find difference between the performance of the operated knee compared to the contralateral one. Ozenci et al. and Reider et al. reported no significant difference in proprioception when ACL-reconstructed limbs were compared to the uninjured contralateral ones (39, 40), in accordance with our data. It should be mentioned that these data have to be confirmed by studies with larger populations. However, it is interesting to observe that an ACLR with BTPB allograft enables a restoration of proprioceptive capacity and stability of the limb similar not only to a hamstring autograft, but also to a native ACL.

Although we examined a limited number of patients, no complications or re-rupture occurred in our cohort, nor were there cases of infection or acute synovitis. In contrast, Guo et al. reported 3 cases of acute synovitis between 25 patients who underwent an ACLR with fresh-frozen BPTB allograft (33). Fresh-frozen allogeneic grafts can cause cytokine-induced inflammation and latent immunologic rejection leading to tibial tunnel enlargement (3). Acute synovitis may be the most common symptom of immunologic rejection: it is a condition, like the early infections, in which patients could complain of local swelling, fever, and severe pain.

Primary ACLR with fresh-frozen BPTB allograft could lead to clinical and proprioceptive results comparable to the ones reached with hamstring autograft, but avoiding donor site morbidity. The morbidity associated with harvesting the graft, such as anterior knee pain or quadriceps weakness after the use of autologous BPTB or reduction in knee flexion strength after the use of autologous hamstring tendons, needs to be considered when surgeons plan on performing an arthroscopic ACLR (41). Furthermore, Haviv et al. evidenced that midline incisions for BPTB harvesting could injure the infrapatellar branch and medial incisions for hamstring harvesting could injure the sartorial branch of the saphenous nerve (42): the incidence of infrapatellar branch of saphenous nerve injury in literature has been reported to be as much as 50% with the BPTB autograft technique and 30 to 59% with the hamstrings technique (5, 6).

Healthcare systems all over the world put an increased emphasis on understanding the cost drivers and high-value procedures within orthopedics. Recently, an important cost-effectiveness meta-analysis showed that the use of allograft in ACLR normally leads to higher costs compared to hamstring autograft (43), but the probability of different post-operative complications may induce surgeons to choose either BPTB allografts or autografts (42). Moreover, cost-effectiveness analysis could not replace the judgment of the individual clinician in a multifactorial decision like that of graft choice for ACLR, which must be taken based on clinical case and patient characteristics.

Several potential limitations may have influenced the results of our study. Firstly, its retrospective na-

ture and the absence of randomization; secondly, the groups of patients are small and the follow-up time is intermediate.

However, to the best of our knowledge, no previous study has compared both clinical and proprioceptive outcomes between groups of patients who underwent ACLR with BPTB allograft or GST autograft by the same surgeon, with the same surgical technique and in the same structure.

Conclusions

In conclusion, this study highlighted the good clinical and proprioceptive outcomes at medium-term follow-up of ACLR with BPTB allograft and GST autograft. Further, the data confirmed that BPTB allograft is comparable to GST autograft when comparing clinical outcomes, antero-posterior laxity, failure rates and the recovery of proprioceptive ability. However, the BPTB allograft seems to enable an earlier return to work and sport compared to GST autograft. Further research with larger cohorts of patients are needed to make a more extensive comparison.

Declarations: All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Translation, cross-cultural adaptation, reliability, and validation of the Italian version of the American Orthopaedic Foot and Ankle Society - MetaTarsoPhalangeal-InterPhalangeal Scale (AOFAS-MTP-IP) for the hallux

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Summary. *Background and Aim of the work:* An incorrect interpretation or patients' misunderstanding of evaluation scales can induce a mistake; therefore the real applicability of an evaluation scale should be determined by procedures that take care of cultural adaptability and not only of scientific validity. Our purpose was to translate and culturally adapt into Italian the AOFAS-MTP-IP scale for hallux, and to check its reproducibility and validity. *Methods:* The AOFAS-MTP-IP scale was processed for translation and checked for medical part coherence. The scale was submitted to 10 patients to verify a correct cultural adaptation. Then, the scale was submitted to 50 randomized patients operated at their hallux. Intra and inter-observer reproducibility was checked by two interviewers and a repeated interview. Short-Form-36-questionnaire for Quality of Life and Visual-Analogue-Scale for pain were also administered to perform validation analysis. The Pearson's-Correlation-Coefficient and the Intra-Class-Correlation coefficient were calculated to analyse the scale reproducibility and validation. *Results:* Cultural adaptation of the translated version of the scale resulted good in terms of understandability by patients. An optimal correlation of the inter and intra-observer reproducibility was obtained. The correlation with well-known validated scales as SF-36 and VAS has shown good correlation indicating success in the validation process. *Conclusions:* Validation of the Italian version of the AOFAS-MTP-IP evaluation scale for hallux has been performed successfully. Therefore its use can be considered appropriate and suggested in Italian clinical practice. (www.actabiomedica.it)

Key words: evaluation scale, hallux, validation, Italian, cultural adaptation, metatarsophalangeal joint (MTP), AOFAS

Introduction

Injuries and pathologies of the foot are frequently affected by a long recovering time, owing to continuous stimulation of the anatomical part during orthostatic posture and walking. In this contest it is important monitoring the status or the evolution of the injury: therefore several orthopedic scales for the evaluation of conservative or surgical treatments have been performed.

Questionnaires are constructed by several items that focus on the evaluation of different patients' performances during their daily life, to assess the patient's subjective condition. These scales allow physicians to have indications on real ameliorations or permanence of disabilities following the therapeutic intervention,

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to estimate the real impact on the performance of patients' daily life activities (1).

Most part of these questionnaires was created in English-speaking regions; therefore, they are the result of the socio-linguistic tradition of these areas and their applicability in other areas, in which different socio-linguistic traditions exist, may generate interpretative difficulties.

This is a critical point in the use of these scales, because they were born and used with the intention to produce subjective response by patients, to evaluate the efficacy of the clinical intervention in relationships to individual patients' satisfaction and wellness. A non-correct interpretation or patients' misunderstanding can induce an evaluation mistake and make useless the application of these evaluation scales.

Guillemin (2) was the first to introduce the need of a careful translation procedure, in which the scale is not simply translated, but culturally adapted to the language to maintain the same evaluation properties; furthermore the translated scale needs to be statistically verified to give it a scientific validity for a proper use of its outcomes. Indeed, scientific validity of a scale outcomes is a point of great importance, because it allows to use homogeneous data about patients for allowing a more precise comparison among patients with a similar pathologic condition (3). In these terms, in the case of clinical conditions that *in sè* may not directly produce meaningful data, evaluation scales offer to scientists the availability to manage subjective data and related questions useful to address the analysis of clinical protocol in their impact on health-related quality of life (4).

The American Orthopedic Foot and Ankle Society Score (AOFAS) is one of the most widely used clinician-reporting tools for foot and ankle conditions. Developed in 1994, AOFAS is a clinician-based score that measures outcome for four different anatomic regions of the foot: the Ankle-Hindfoot, Midfoot, MetaTarsoPhalangeal (MTP)-InterPhalangeal (IP) for the Hallux, and MTP-IP for the Lesser Toes. The four anatomic regions of the AOFAS are all represented by a different version of the survey with each tool designed to be used independently (5).

Aim

In the present work we intended to perform a cross-cultural adaptation in Italian language of the American Orthopaedic Foot and Ankle Society - MetaTarsoPhalangeal (MTP)-InterPhalangeal (IP) Scale (AOFAS-MTP-IP) for the hallux and we also aimed to verify the reliability, and validity of the Italian version.

Materials and method

To assure that an italian translation of AOFAS-MTP-IP was not already in use, or recently proposed, we performed a Medline/PubMed search typing the keywords: "AOFAS hallux score Italian validation" and the search didn't find any previous Italian version.

We started the translation and the cultural adaptation following a process of three different stages as proposed by Guillemin (2, 6).

The First Stage consists in: primary translation of the AOFAS-MTP-IP questionnaire, from English into Italian, made by two translators aware of the study, namely an orthopaedic surgeon (M.L.), and a university student (P.L.) involved in non-medical disciplines; both translations were compared and discussed to obtain a unique version.

The Second Stage consists in: submission of the first Italian version to a native English translator, who was unaware of the study and of the original English version of the scale; the translator had to back-translate the AOFAS-MTP-IP scale from Italian to English. We gained a new English version from the native translator and we compared this one to the original to define a second correct Italian version; this step is important to verify and eventually change or shift of significance related to linguistic expression during translation procedure (7).

The Third Stage consists in: cultural adaptation of the translated questionnaire. We have enlisted randomly 10 patients with hallux orthopedic disease retrieved from the hospital DataBase "AcceWeb" (Hi. Tech S.p.A. Software Engineering, via di Campigliano 51, 50012 Bagno a Ripoli, Firenze, Italy); no particular conditions were required for enlistment like age, sex or nationality.

All patients gave their informed consent for participation in the research study.

To those who tested the second Italian version of AOFAS scale was added the question "difficult to understand?" to each sentence. We posed the limit of 90% of patients understanding the Italian questionnaire to indicate a good translation; otherwise we should have to restart from the first step of the process to try to improve the cultural adaptation.

We also submitted the AOFAS scale to 10 healthcare professionals (3 orthopaedists, 2 physioterapists, 2 medical specialists, 3 nurses), to check the comprehension of the medical part that consists in: MTP joint motion (dorsiflexion and plantarflexion), IP joint motion (plantarflexion), MTP-IP stability (all directions), callus related to hallux (MTP-IP) and alignment. The comprehension of the text by healthcare professionals had to be as for patients with a positive feedback of at least 90% to continue with the following steps, otherwise, even in these cases, we should have to restart from the first stage for searching a translation improvement.

Assessment of reproducibility and validity of the Italian version of the AOFAS-MetaTarsoPhalangeal - InterPhalangeal questionnaire for Hallux

The Italian AOFAS-MTP-IP was administered to a randomized group of 50 patients (with regular informed consent) who had undergone a surgical procedure at our institution for the treatment of hallux orthopedic disease. We considered a minimum follow-up of 3 months and thus included patients operated from 01/04/2017 to 31/03/2019. The 10 patients previously recruited to assess the cultural adaptation of the evaluation scale were also included in this group. Each patient of the group was submitted to three interviews made by two previously trained and independent interviewers (interviewers A and B). The first interview was made by A and the same day after 30 minutes it was made by B: this step was necessary to check the inter-observer reproducibility. Within 15 days, interviewer A had to reassess all the patients with the Italian AOFAS-MTP-IP questionnaires to check the intra-observer reproducibility. At the moment of the first interview, interviewer A also submitted the SF-36 questionnaire for Quality of Life and Visual Analogue Scale (VAS) to measure pain, in order to gain data to proceed to AOFAS hallux scale validation.

Statistical Analysis

Clinical and demographic data of the assessed patients were characterized.

The Pearson's Correlation Coefficient (PCC) and the Intra-Class Correlation (ICC) coefficient were calculated to check the inter and intra-observer reproducibility for validation.

All statistical procedures were performed by STATA13.0 statistical program.

Results

Translation and cultural adaptation

The AOFAS specific questionnaire for the hallux (Table 1) consists of eight items: Pain, Activity limitation, Footwear requirements, MTP joint motion (dorsiflexion plus plantarflexion), IP joint motion (plantarflexion), MTP-IP stability (all directions), Callus related to hallux MTP-IP and Alignment. These items are distributed over three categories: Pain (40 points), Function (45 points) and Alignment (15 points).

The maximum possible score is 100 points and consists in no pain (40 pt), no activity limitations (10 pt), no footwear requirements (10 pt), normal MTP joint motion (10 pt), no restriction of IP joint motion (5 pt), MTP-IP stability in all directions (5 pt), no callus or callus asymptomatic (5 pt) and hallux well aligned (15 pt).

The minimum score is 0 points and consists in the worst possible condition for our patients that will have a severe and almost always present pain, a severe limitation of daily and recreational activities, a modified shoes or brace, a severe restriction of MTP and IP joint motion, a MTP/IP articulation definitely unstable or able to dislocate, a symptomatic callus, a poor or obvious symptomatic malalignment of the hallux.

During the dispensing of the questionnaire for checking the cultural adaptation, six patients out of the ten, found difficulties to understand the second item

Table 1. Scala di valutazione AOFAS metatarsofalangea (MF) - Interfalangea (IF) dell'alluce (versione italiana validata da Leigheb et al.)

I Dolore (40 punti)	
Nessuno	40
Lieve, occasionale	30
Moderato, quotidiano	20
Severo, quasi sempre presente	0
II Funzione (45 punti)	
Limitazioni nelle attività quotidiane, lavorative e ricreazionali	
Nessuna	10
Lieve	7
Moderata	4
Severa	0
Requisiti per le calzature	
Scarpe alla moda, comuni, senza necessità di plantari/solette	10
Calzature comode, plantari/solette	5
Scarpe modificate o tutore ortopedico	0
Articolarità MF (dorsiflessione più plantarflessione)	
Normale o lieve limitazione (75° o più)	10
Limitazione moderata (30°-74°)	5
Limitazione severa (meno di 30°)	0
Articolarità IF (plantarflessione)	
Nessuna limitazione	5
Severa limitazione (meno di 10°)	0
Stabilità MF-IF (tutte le direzioni)	
Stabile	5
Decisamente instabile o lussabile	0
Callo relativo a MF-IF dell'alluce	
Nessun callo o callo asintomatico	5
Callo sintomatico	0
III Allineamento (15 punti)	
Buono, alluce ben allineato	15
Discreto, osservato qualche grado di malallineamento dell'alluce, asintomatico	8
Scarso, evidente malallineamento sintomatico	0
Cognome e nome pz: **Lato:** Dx Sin **Data compilazione:**	**Totale:** /100

(the Activity Limitation item), for which they required explanations, therefore this item of the scale, did invalidate the proposal of good comprehension level settled at 90% of patients. Because in any other items the patients have shown to have difficulties to understand and no improper translation was revealed inside the second item, the same was subject to a re-evaluation in its cultural adaptation. The re-evaluation process has brought to a proposal of a different item that gave no difficulty to understand (Table 2). All healthcare professionals interviewed for checking the medical part comprehension didn't find any difficulty with the first translation nor with the second one.

Table 2. Different translation of the second item to better perform the cultural adaptation of the item

First literal translation of the voice "activity limitation" of the AOFAS-MTP-IP

II Funzione (45 punti)

Limitazioni nelle attività	
Nessuna limitazione	10
Nessuna limitazione delle attività quotidiane, come quelle lavorative	7
Attività quotidiane e ricreazionali limitate	4
Severa limitazione delle attività quotidiane e ricreazionali	0

Second translation culturally adapted of the voice "activity limitation" of the AOFAS-hallux scale.

II Funzione (45 punti)

Limitazioni nelle attività quotidiane, lavorative e ricreazionali	
Nessuna	10
Lieve	7
Moderata	4
Severa	0

Statistical reproducibility and validity of the Italian version of the AOFAS-MPT-IP scale

To assess the validity of the scale, we randomly enlisted 50 patients, including 82% females and 18% males, with diagnoses of hallux valgus (72%, N=36) and hallux rigidus (28%, N=14): according to ICD-9 classification (International Classification of Diseases, 9th edition) respectively 735.0 and 735.2. Other demographic parameters are shown in Table 3.

The time elapsed between the two interviews performed by the interviewer A was not the same for each patient, but all were interviewed after a minimum interval of 7 days and a maximum of 21.

The data evaluation (PCC analysis) for every item of the AOFAS-MTP-IP scale collected by interviewer A, are detailed in Table 4, whereas the comparison of the total scores collected by the interviewer A in the first and in the second time and by the interviewer B are resumed in Table 5.

PCC evaluation results, can be read in the following way: 0 < PCC < 0.3: weak correlation; 0.3 < PCC < 0.7: moderate correlation, 0.7 < PCC > 1.0: good correlation.

Table 3. Characteristics of the 50 patients included in the translation and validation process of the AOFAS-MTP-IP scale

Sociodemographic aspects	Values
Male gender	9
Female gender	41
Age (years): average	61±9
Age (years): range	45-80
Ethnicity: Caucasian	98%
Ethnicity: Non Caucasian	2%
Elapsed time after surgery (in months): average	3

The analysis related to the reproducibility of scale outcomes, concerning inter- and intra-interviewer variability is resumed in Table 6.

The reproducibility evaluated by Pearson's Correlation Coefficient (PCC) show a good correlation for two items ('Pain' and 'Footwear requirement), a moderate correlation for three items, while the items 5 (IP Joint motion, plantar-flexion), 6 (MTP-IP stability, all

Table 4. AOFAS-MTP-IP scores at the first interview

AOFAS-MTP-IP Questions/Items	Mean	SD	Maximum	Minimum
Pain	32.2	10.0	40	0
Activity limitation	8.4	2.5	10	3
Footwear requirements	3.8	1.3	5	0
MTP joint motion (dorsiflexion plus plantarflexion)	6.2	2.8	10	0
IP joint motion (plantarflexion)	5.0	0.0	5	5
MTP-IP stability (all directions)	5.0	0.0	5	5
Callus related to hallux MTP-IP	5.0	0.0	5	5
Alignment	13.7	2.7	15	8

Table 5. AOFAS-MTP-IP total scores detected following the different interview performed on patients

Observer	Mean ± SD	CL 95 %
A	79.3 ± 13.3	75.6 – 83.0
Abis	78.8 ± 12.2	75.4 – 82.2
B	80.0 ± 12.2	76.6 – 83.4

directions) and 7 (Callus related to hallux, MTP-IP) do not display any PCC value, owing the occurrence of a binary response (0 or 5), that in the clinical cases examined have produced the same response (constant value = 5), this event makes PCC evaluation unable to produce results. The intra-interviewer coefficients are generally lightly higher than inter-interviewer coefficients, evidencing a high coherence of response obtainable with the scale (Table 6).

The Intra-Class Correlation (ICC) coefficient used to assess the reproducibility was compared with the Pearson's correlation coefficient (Table 7); the analysis confirms the occurrence of a strong identity among the different scores detected by interviewer A vs. Abis and A vs. B, allowing us to judge optimal the correlation in terms of inter and intra- interviewer variability.

In conclusion the analysis evidences an optimal level of reproducibility, indicating the Italian version of AOFAS-MTP-IP scale as adequate for the use by different interviewers.

Table 6. Assessment of intra and inter-interviewer reproducibility of AOFAS-MTP-IP scale with Pearson correlation coefficient

AOFAS-MTP-IP Questions/Items	Pearson Correlation Coefficient	
	Intra-Interviewer	Inter-Interviewer
Pain	0.8715	0.8799
Activity limitation	0.6269	0.6052
Footwear requirements	0.7844	0.6630
MTP joint motion (dorsiflexion plus plantarflexion)	0.6425	0.6070
IP joint motion (plantarflexion)	n.d.	n.d.
MTP-IP stability (all directions)	n.d.	n.d.
Callus related to hallux MTP-IP	n.d.	n.d.
Alignment	0.6309	0.6021

n.d. = not detectable, owing the occurrence of constant values report

Table 7. Analysis of the reproducibility by means of the Pearson's correlation coefficient and of the intra-class correlation coefficient values for the total score of the AOFASMTP-IP assessment scale

	Intra-Interviewer	C.L. (95%)	Inter-Interviewer	C.L. (95%)
Pearson's Coefficient	0.8788		0.8832	
Intra-Class Coefficient, individual	0.8810	0.8000 – 0.9305	0.8809	0.7994 – 0.9306
Intra-Class Coefficient, average	0.9367	0.8889 – 0.9640	0.9367	0.8885 – 0.9640

Table 8. Correlation with Pearson's coefficient, of the 8 domains of SF-36 with AOFAS-MTP-IP total score results obtained from interviewer A the first time

SF-36 domains	Pearson's coefficient
Physical functions	0.4862
Role physical	0.3335
Bodily pain	0.3491
General health	0.5843
Vitality	0.5052
Social function	0.4704
Role emotion	0.5332
Mental health	0.4266

Table 9. Correlation with Pearson's coefficient of the VAS scale for pain AOFAS-MTP-IP total score results obtained from interviewer A the first time

AOFAS-MTP-IP scores	Pearson's coefficient
Total score, interviewer A	- 0.5271
AOFAS-MTP-IP, first item score (pain)	- 0.5204

The validation of the Italian version of AOFAS-MTP-IP scale was performed in comparison to the 8 domains of SF-36 health quality survey by the PCC (Table 8). The PCC coefficients show a general moderate correlation; in particular for the items 'Role physical' and 'Bodily pain'; we observe values the are at limit between the weak and moderate correlation.

It is known that the occurrence of an item presenting binary response (as evidenced above) strongly reduces the intrinsic variability of the items, affecting the total scale value, that is used for the comparison with SF-36 scale items. This results in lower values than that we could obtain if all items of AOFAS-MTP-IP scale presented three or more choice.

For further control, we compared the AOFAS-MTP-IP Italian scale total values of the interviewer A with the VAS scale; similarly we compared the first item of the Italian version scale (Pain) with VAS scale (Table 9), being the first item related to the same concept of the VAS i.e. the pain. In both cases similar moderate correlation was obtained, indicating the repetition of the limits of AOFAS-MTP-IP scale as above evidenced. The negative sign in the PCC coefficient indicate that the value sequence of the two evaluation scales are displayed in opposite direction.

Discussion

Many questionnaires have been produced to investigate properly the different clinical or disease patterns in the musculoskeletal field, because a generic questionnaire cannot capture the full patients experience in a particular disease (8). Therefore, different questionnaires have been created to investigate specific orthopaedic diseases, giving to the clinicians the opportunity to obtain a correct evaluation on the impact of a specific disease and its related therapeutic intervention.

The AOFAS-MTP-IP scale for hallux is a specific tool investigating a focus orthopedic aspect of both non-operated patients and patients who have undergone a surgical operation, because it has been demonstrated that the degree of deformity, amount of correction, or type of operation did not influence the outcome (9). These evidences have brought to an increasing interest in the use of this scale among orthopedists, physiatrists and physiotherapists.

Using subjective scales, the major point to obtain a correct response by patients consists in the immediate intelligibility of the several items composing the scale, because a use of long and repeated explanation by healthcare workers can alter the result in terms of reliability of the response (7). Therefore, working with subjective evaluation scales, the cultural adaptation more than the translation is a critical point to obtain a useful tool, the outcome of which can be used properly. We have observed the importance of this concern in the cultural adaptation process of the second item. In spite of its intelligibility by professional workers, the immediate understanding of this item by the most part of patients is not good, and they required further explanations to respond adequately. Instead an adapted version of the point didn't offer any incertitude by patients. Therefore, under the highlight of this result we further pointed out the importance of do not use evaluation scale that has not culturally validated.

The major point in the use of subjective scales is represented by their reliability, consisting into producing data that have an intrinsic objective validity and scientific consistence, to be used in comparison with other similar data, allowing to an interchange of experiences and therapeutical interventions among clinicians. The scientific validation of the subjective scales has a recognized protocol that has in ICC coefficient and in the PCC evaluation the statistical procedure, and in the SF-36 and VAS scale the comparison counterpart (10).

In our analysis we did not obtained a high level of positive correlation that might indicate a limited validity of the translated scale; indeed AOFAS-MTP-IP scale has weak points in the items 'IP Joint motion, plantar-flexion', 'MTP-IP stability, all directions', 'Callus related to hallux, MTP-IP', that are all characterized by a binary response. In fact, the binary response makes a reduced variability of the investigative response, performing a weakening of the validation procedure (PCC evaluation) *in sè*. In our analysis the constant response of some items further lowered the resolutive properties of the PCC evaluation. We may assume that the theoretic limit of the PCC test cannot be considered = 1, but should be considered lower, approximately 0.8 or 0.7. Following this consideration PCC evaluation outcomes such as 0.5 become values to be interpreted as good results.

In spite of the wide consensus that the AOFAS-MTP-IP scale for hallux have gained among clinicians, this scale offers some critical point in the variability of the outcomes that can report.

Curiously, patients treated with arthrodesis for hallux rigidus have a mandatory null item score on the MTP-joint mobility: this makes more rigid the evaluation potentiality of the scale. These limitations should induce clinicians to be aware in the use of the AOFAS-MTP-IP scale, and to verify its effective applicability.

In conclusion, validation and cross-cultural adaptation of the AOFAS-MTP-IP Italian version has been performed successfully and its use can be considered appropriate and suggested in Italian clinical practice.

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Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Original article

Ten year challenge with Ponseti method for clubfoot: our experience

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Summary. Equino-varus-adducted-supinated, also known as clubfoot, is the most frequent congenital malformation of the foot. Scientific evidences of the last decades has definitively confirmed the efficacy of the non-invasive Ponseti Technique, which is based on manipulation, plaster casts, percutaneous achillean tenotomy and stabilization of the foot using a brace. The aim of the article is to describe the experience of our third level hospital in treating clubfoot with Ponseti Method. Our data are similar to the ones in literature, confirming the effectiveness and good reproducibility of the Method. (www.actabiomedica.it)

Key words: congenital clubfoot, Ponseti Method, Achilles tenotomy, brace

Aim of the work

To describe the experience of our third level hospital in treating clubfoot with Ponseti Method and to compare the obtained results with those proposed by the scientific literature.

Background

Clubfoot (or equino-varus-adducted-supinated) is the most frequent congenital malformation of the foot. It is estimated that, in the world, 1-2 newborns every 1000 are affected by this pathology (150,000-200,000 newborns per year), with a male to female ratio of 2:1 and a major distribution in developing countries (80%) (1). Clubfoot is a complex deformity. It affects both feet in 50% of cases (2). If affected children will not properly be treated, they will not be capable to live a normal life because they will never be able to walk adequately. Over the decades, different corrective solutions have been proposed with varying degrees of invasiveness (3). Surgical treatment for clubfoot is frequently associated with complications, with the final result of a foot that hardly reaches a complete functionality due to retractions and scarring secondary to the surgery itself (4). Scientific evidences of the last decades has definitively confirmed the efficacy of the non-invasive Ponseti Technique, which is based on manipulation, plaster casts, percutaneous achillean tenotomy and stabilization of the foot using a brace (5, 6). The Ponseti Method should start as soon as possible (between 7 and 10 days of life) and consists of manipulations of the foot followed by the application of a plaster cast, usually 5 or 6 casts are needed to correct supination and abduction deformity. The first femoropodalic cast must stay in place for 5-7 days, during this period the ligamentous structures adapt to the new position. After this term the cast is removed, the foot is re-evaluated, a new chalk is manipulated and positioned, and again it will work to progressively softner capsule-ligament structures to maintain the new position. This procedure is repeated until the correction of cavism and subsequently adduction and varism is reached. At the end of that period, if equinism is still present, we proceed with a minimally invasive tenotomy of the Achilles tendon. This is a 5-minutes lasting procedure, followed by the positioning of a cast

that will allow the tendon to heal in elongation (on average 20 days) (7). In order to maintain the correction obtained and prevent recurrences, it is essential to use the Mitchell-Ponseti brace (8).This brace has to be worn with a day night schedule that develops with the child age and the personal answer to the treatment. After the removal of the last cast, for the following 3 months, the Ponseti brace must be worn full time (23 hours per day) and then gradually reduce to 12-14 hours per day from 1 year up to 5 years of age (figure 1) (9, 10).

Materials and methods

We retrospectively examined all the cases of clubfoot treated with Ponseti Method from 2009 to 2019 in the Pediatric- Orthopedic Department of Burlo Garofolo Hospital in Trieste, Italy. The medical records of patients with clubfoot treated with Ponseti Method were reviewed. The inclusion criteria for the treatment was a congenital clubfoot which was clinically diagnosed. Exclusion criterion was the presence of previous clubfoot treatment and the premature quit of the treatment. We used Pirani Clinical Score to evaluate clubfoot severity (11). The clinical evaluation was performed before the first manipulation and cast application; subsequently we made a clinical evaluation with Pirani score at every cast replacement.

Results

In the present study 96 children were treated: 62% had bilateral clubfoot and 38% monolateral of which 20% right and 18% left. We had 73% boys and 27% girls patients, an higher rate of males and bilateral feet if compared with literature (12). In a further article, althogh this evidence, Zionts et al. demonstrated that there is no difference in severity of clubfoot due to sex. Farther, on average, bilateral patients did not have increased severity, but a larger range of severity compared with those who have unilateral deformity (13). The mean Pirani score in our patients was 5.77, only 5 children had a Pirani score lower than 5. The mean number of plaster cast used was 5.62 per patient, with a minimum of 3 and a maximum of 9 casts. To eliminate residual equinus, it is required an Achillles percutaneous tenotomy (figure 2) followed by three weeks of casting to aid healing the tendon. In our study the tenotomy was realized in 92,7% of the patients. According to major studies Achilles tenotomy is required in all the children with initial Pirani score greater than 5, while in patients with a Pirani score lower than 3 it seems not needed (14). The maintenance phase then involved holding the foot in an extrarotation and dorsiflexion brace (The Mitchell-Ponseti brace) for 23 hours per day for 3 months. Progressively, the time of use of the device can be decreased until 12 -14 hours (worn during the night) until five years of age (9). However, we use an individualised protocol for each children.

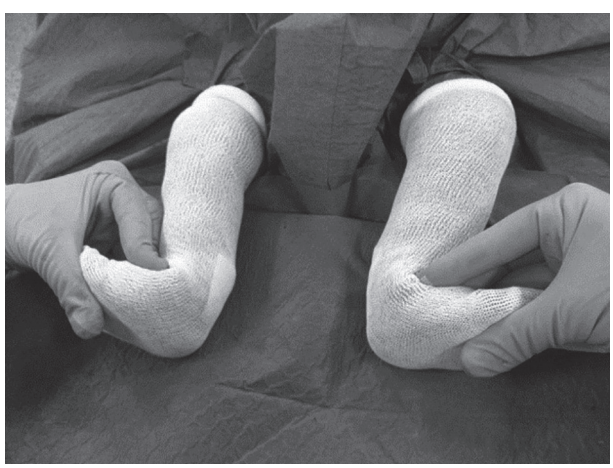

Figure 1. Brace position after Achilles tenotomy

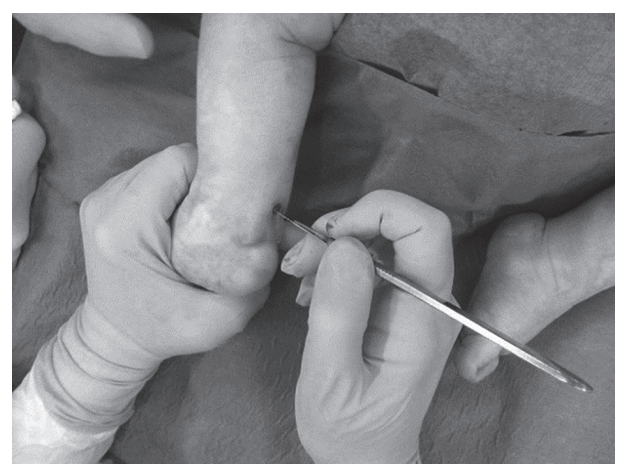

Figure 2. Achilles tenotomy

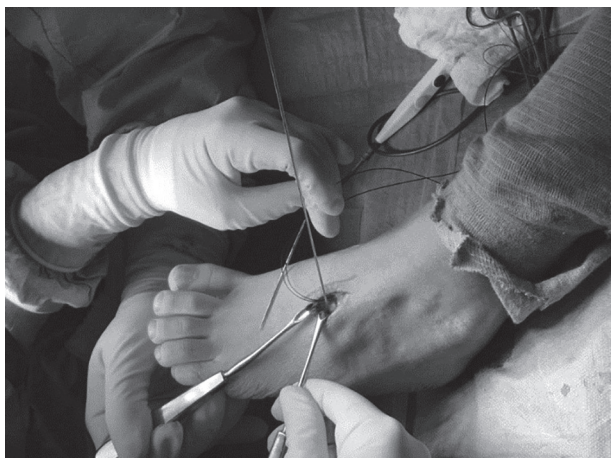

Figure 3. A phase of TA transposition

The most dreadful complications is recurrence. The lack of family compliance to the bracing protocol is the leading cause of relapses and failure of the treatment (15). In a study of 73 feet treated with Ponseti Method, 24 showed recurrence (33%), and the only relevant correlation was the noncompliance to the brace (16). We observed a relapse rate of 10,4% (10/96 children), that conforms to literature where minimum relapse rate is 3,7% (17) and the maximum relapse rate was 27.1% (18). While 6 out of 10 children showed a complete response to the recasting only for relapse, 4 of them needed both recasting and surgical treatment. The surgical procedures consisted of: Achilles Z lengthening and posterior subtalar and ankle capsulotomies (2 children), Achilles Z lengthening, posterior subtalar and ankle capsulotomies and TA transposition (figure 3) (2 children). In our experience the causes of the relapses have to be found in the early interruption of the treatment, co-morbidity and bad compliance to the use of the brace.

Conclusions

The Ponseti Method is, currently, the "Gold Standard" for congenital clubfoot. In 2012, a survey of member ship of the Pediatric Orthopedic Society of North America indicated that 96,7% use the Ponseti Method to treat clubfoot (19). A systematic review of 2014 shown that 113 countries (59%) all over the world performed the Ponseti Method. This treatment with

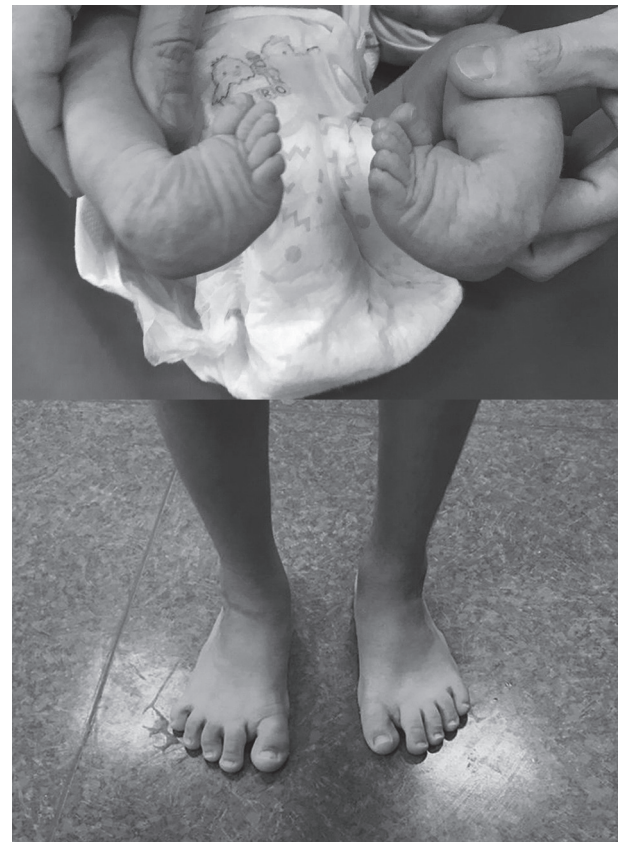

Figure 4 a, b. The clinical case of A. V. a) First day of Treatment, b) 7 years old

its small rate of complication, low cost, and elevated effectiveness, has a great potential to treat clubfoot in both developed and undeveloped countries (20). It does not require major surgery, unless the recurrence of relapses, but to succed it is also very important a primary commitment from the family. The first step is prenatal diagnosis and counselling, where the specialist explains the Ponseti Method and enstablish the first contact with the parents of the future patient. During the first post natal evaluation the doctor reaffirm the importance of the Method and its phases, underlining the importance of the family compliance to it. The very success of the Method is related to an early onset of the treatment, the correct use of the brace in order to prevent the relapses and to the attentive participation to the scheduled follow ups (figure 4A and B). Our data are similar to the ones in literature, confirming the effectiveness and good reproducibility of the Method (21).

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Two cases of neglected posterior fracture-dislocation of the shoulder with ipsilateral humeral shaft fracture

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Summary. Posterior shoulder fracture-dislocations are rare. A combination of this injury with ipsilateral humeral shaft fracture is an extremely rare event. We report two cases of posterior shoulder fracture-dislocation with ipsilateral fracture shaft of humerus treated in our department. We highlight the rarity of the condition and the potential risk of recognize only the shaft fracture. We emphasize the importance of complete physical and radiological examination (x-rays and CT scan) in such cases to ensure early detection and its subsequent surgical treatment. (www.actabiomedica.it)

Key words: glenohumeral fracture dislocation, humeral shaft fracture, posterior shoulder dislocation

Introduction

Posterior shoulder dislocations and posterior shoulder fracture-dislocations occur rarely. Posterior shoulder fracture-dislocations associated with humeral shaft fracture are extremely infrequent and, in literature, not even one case regarding the treatment with plate and screws is present (1).

The major critical aspect in these cases, considering the exceptionality, is the accuracy of the preoperative clinical evaluation and the diagnostic assessment to suggest the surgeon the most adequate surgical treatment option and the selection of the correct fixation device to treat the lesion.

Following are two case studies including clinical follow-up evaluation and diagnostic follow-up assessment a year after the traumatic injury treated at our Orthopedic and Traumatology Ward.

Case report No. 1

34 years old male patient (G.M.) transported at the Emergency Room of the Ospedale San Bortolo of Vicenza following to a high-energy motor vehicle accident (motorcycle fall). Patient complained of severe pain and reported impairment at the level of the left upper limb, showing signs of abduction and antalgic position. Swelling was present at the level of the deltoid and proximal humerus. No vessel or nerve deficit was noted.

The two-planes radiological assessment performed in the Emergency Room showed findings of humeral shaft fracture, 12A2 as according to the AO Classification (Fig. 1, 2).

Therefore, immobilization with a Desault-type shoulder brace was performed; patient was admitted to our Orthopedic and Traumatology Ward and recommended to undergo surgical procedure of internal fixation with intramedullary nailing.

Three days after, patient was taken into the operating room and, after being placed on the operating table, underwent fluoroscopy procedure at the level of the head of the humerus showing evidence of posterior shoulder fracture-dislocation of the humeral head (Fig. 3).

Therefore, the surgical approach was modified to an open surgery for reduction of the fracture-disloca-

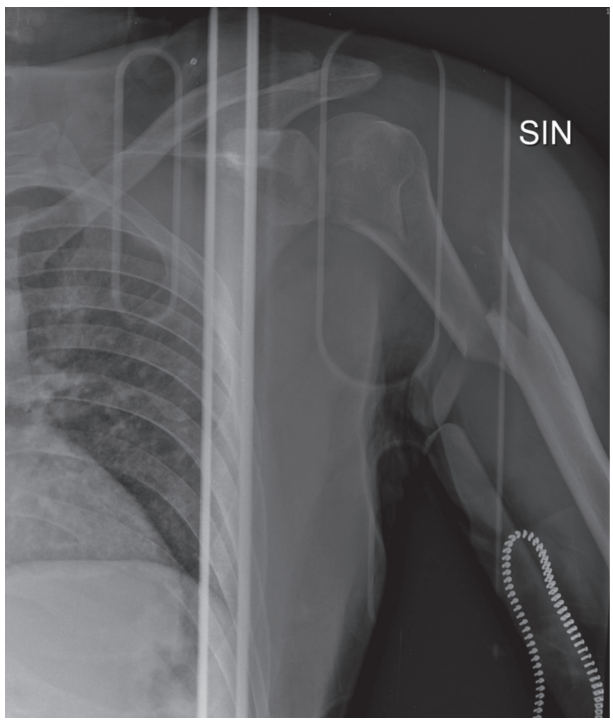

Figure 1. Preoperative X-ray (AP view)

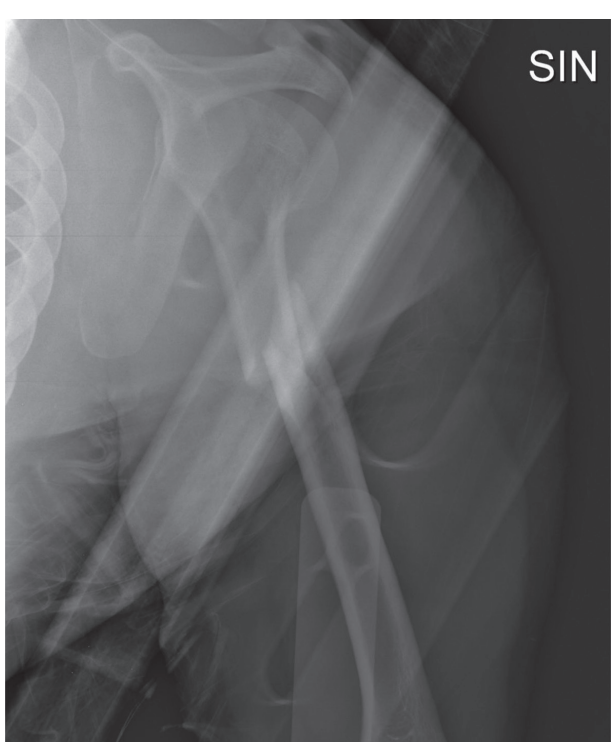

Figure 2. Preoperative X-ray (sagittal view)

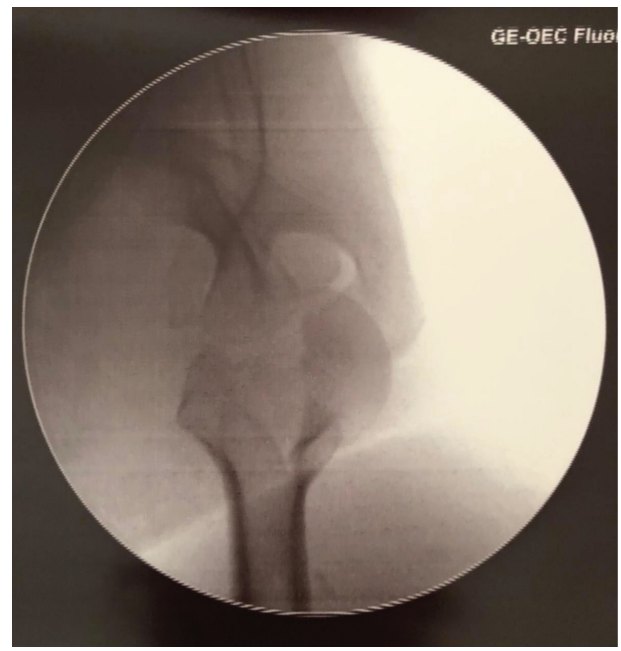

Figure 3. Posterior fracture dislocation at preoperative fluoroscopy

tion of the head of the humerus and the humeral shaft fracture: deltopectoral approach for placement of titanium plate and screws (Philos Depuy-Synthes®) were performed (Fig. 4-6).

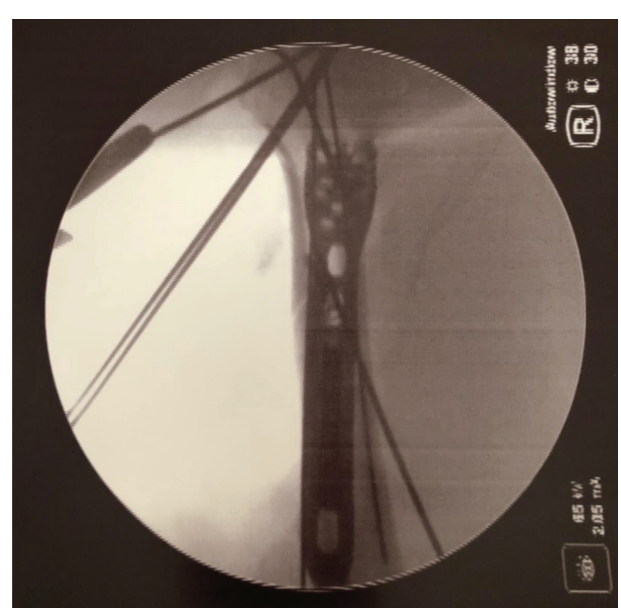

Figure 4. Intraoperative reduction with k-wires an stabilization with plate and screws (sagittal view)

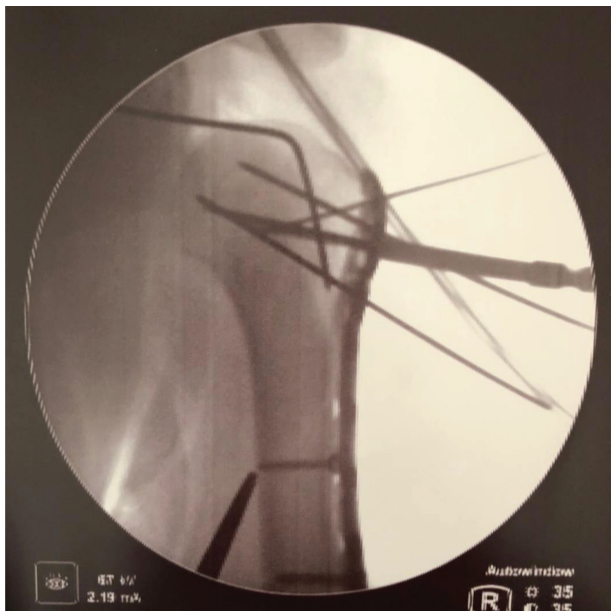

Figure 5. Intraoperative reduction with k-wires an stabilization with plate and screws (AP view)

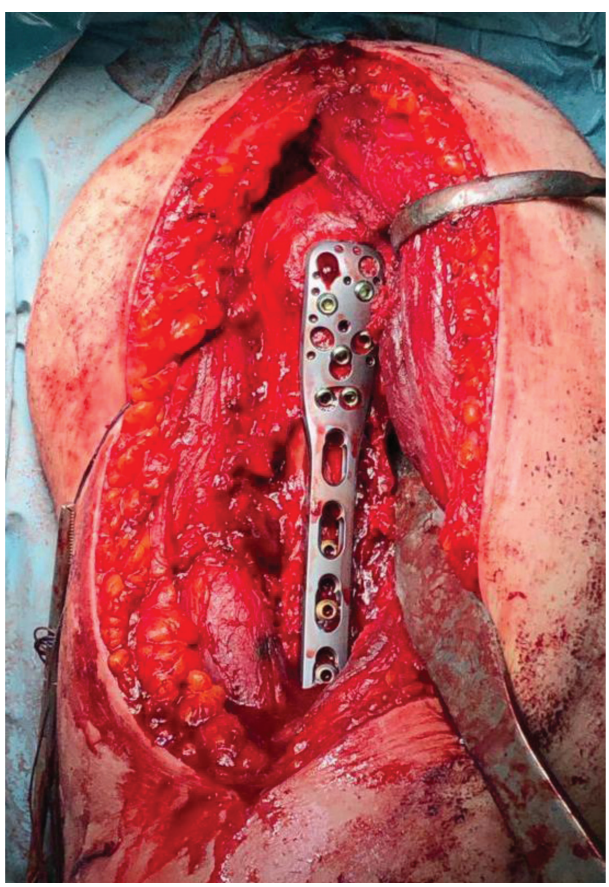

Figure 6. Final position of the plate and screws

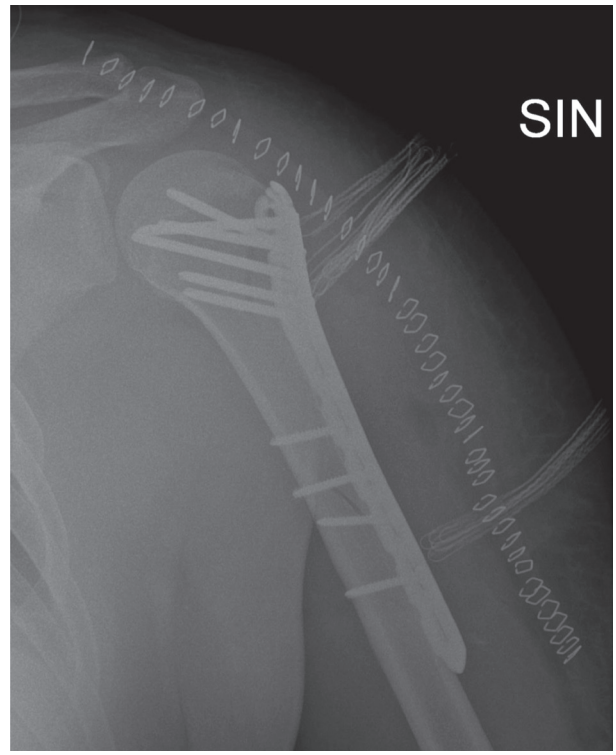

Figure 7. Postoperative X-ray

The postoperative follow-up x-rays performed the night of the surgery showed a reduction of dislocation and fractures (Fig. 7). Patient was discharged later and underwent clinical and radiological follow-up assessments periodically. One year after the surgical procedure, the reduction of the dislocation and of the fractures was maintained, presenting no radiological findings of avascular necrosis (Fig. 8, 9). The anterior flection was 120 degrees, the abduction 110 degrees, the external rotation 30 degrees and the internal rotation was at L1.

Case report No. 2

57 years old male patient (M.M.) transported by the Emergency Services at the Ospedale San Bortolo of Vicenza, following to an accident with an agricultural machinery. Patient presented contusions at the level of the lower limbs and evident swelling of the right shoulder and arm. There was evidence of complete shoulder impairment, but with preserved range of motion and sensitivity of hand and wrist. The x-rays

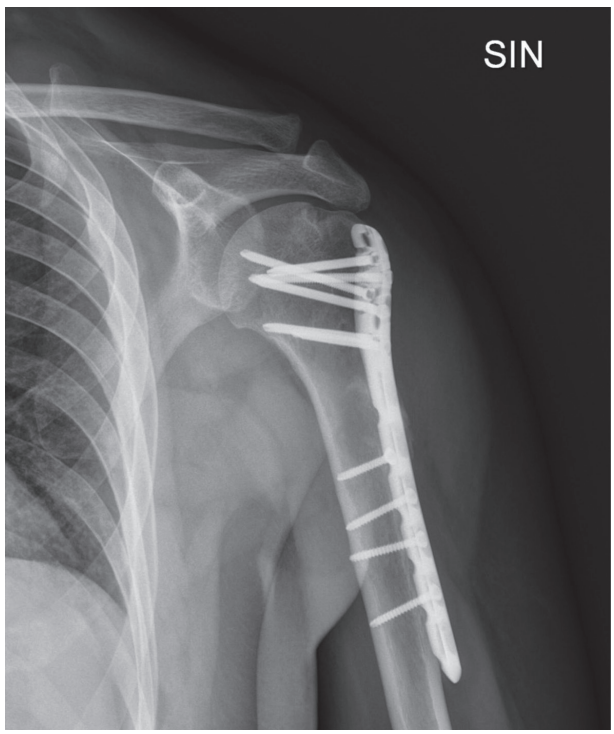

Figure 8. One year follow up x-ray.

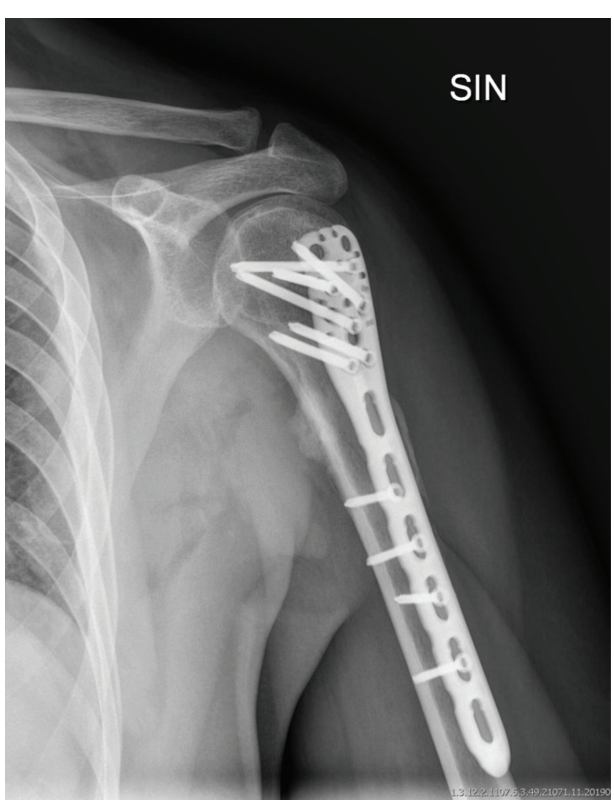

Figure 9. One year follow up x-ray

studies performed at the Emergency Room showed signs of humeral shaft fracture, 12A1 as according to the AO Classification (Fig. 10, 11). Therefore, a Desault-type shoulder brace was placed, and patient was admitted for undergoing surgical procedure of intramedullary nailing.

The following day, after an accurate review of the radiological images, a CT Scan of the proximal humerus was performed with evidence of posterior shoulder fracture-dislocation of the head of the humerus in addition to the previously identified fracture (Fig. 12, 13a, 13b).

Hence, the surgical plan was changed to a reduction of the fracture-dislocation of the humerus and the humerus shaft fracture with (anterior) deltopectoral approach for placement of titanium plate and screws (Philos DePuy-Synthes®).

The postoperative follow-up x-rays and CT Scan (Fig. 14, 15) showed the reduction of dislocation and

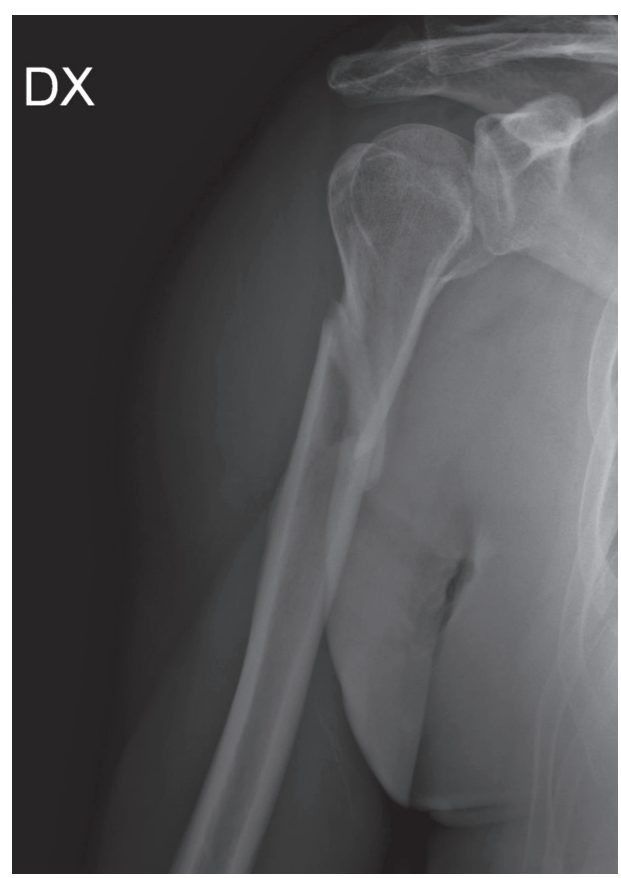

Figure 10. Preoperative X-ray (AP view)

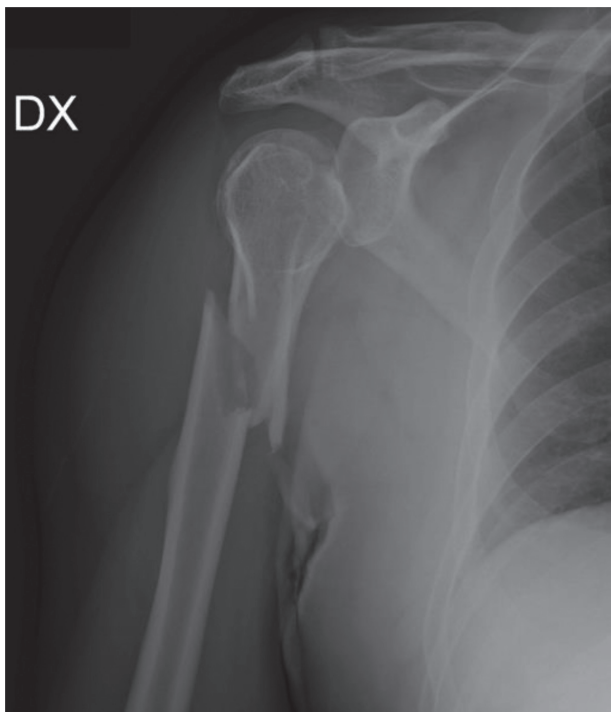

Figure 11. Preoperative X-ray (AP view - intrarotation)

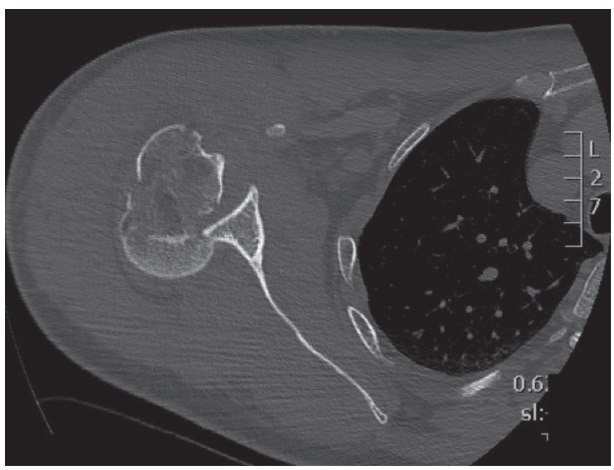

Figure 12. Preoperative CT scan (coronal plane)

fractures. Four months after the surgical procedure, the reduction of the dislocation and of the fractures was maintained, with no radiological findings of avascular necrosis (Fig. 16, 17). The anterior flection was 110 degrees, the abduction 105 degrees, the external rotation 30 degrees and the internal rotation was at L1.

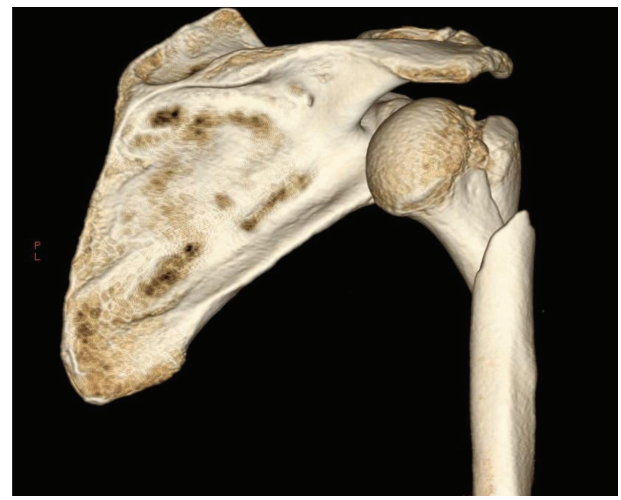

Figure 13a. Preoperative CT scan (3D reconstruction)

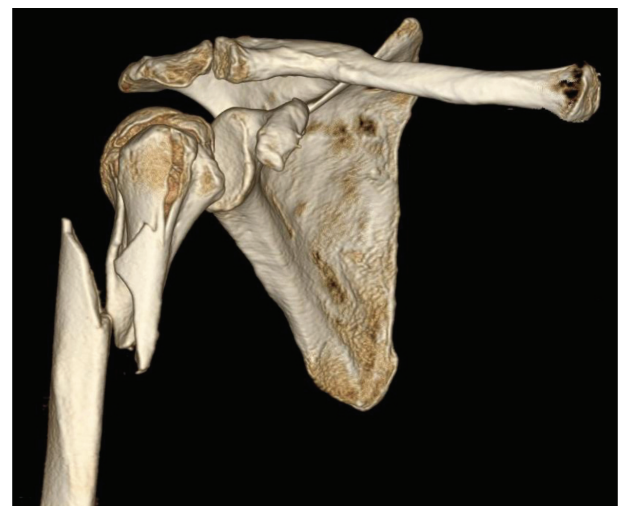

Figure 13b. Preoperative CT scan (3D reconstruction)

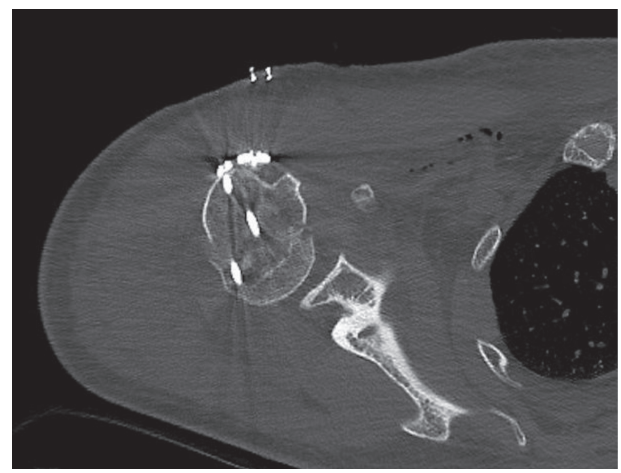

Figure 14. Preoperative CT scan (axial plane)

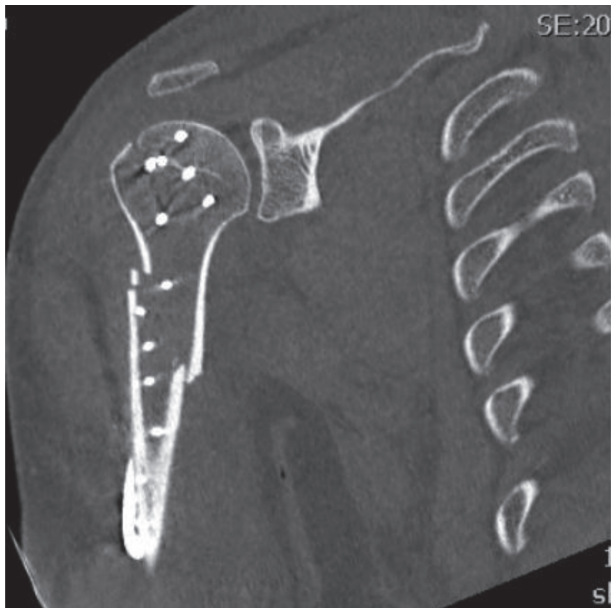

Figure 15. Preoperative CT scan (coronal plane)

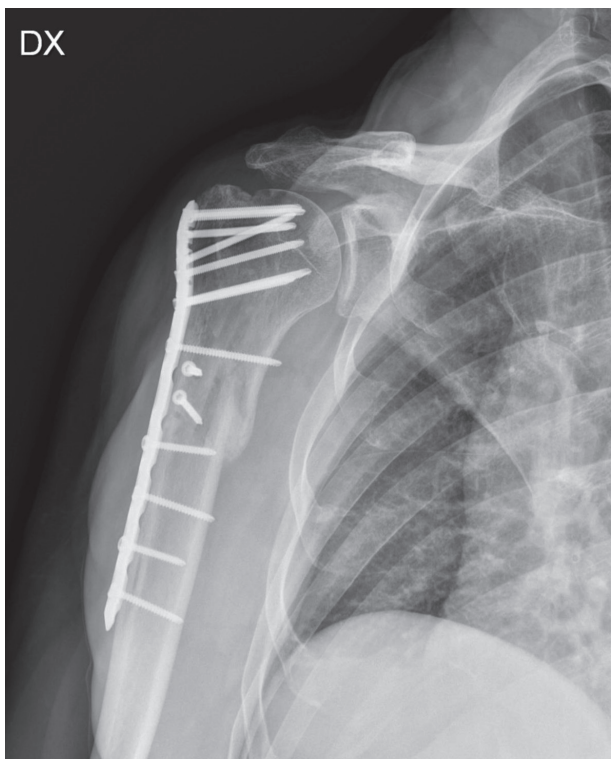

Figure 16. Four months follow up x-ray (AP view)

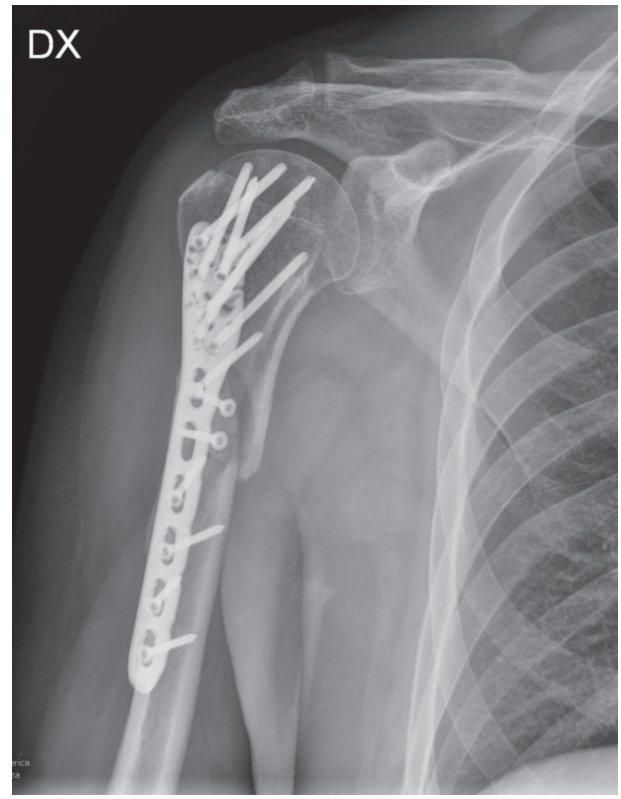

Figure 17. Four months follow up x-ray (AP view - intrarotation)

Discussion

Posterior shoulder dislocation is a rare event, bound to the peculiar resistance of the soft tissues at the level of the posterior region of the joint. In general, this change occurs secondary to excessive and involuntary contractions of the muscles, electroconvulsive therapy, spasticity and seizures (1-5). It can also be associated with high-energy traumatic injuries with the limb in abduction, internal rotation or elevation. The energy absorbed can likewise lead to a fracture of the head in addition to the dislocation, although this type of event is extremely infrequent.

The combination of posterior shoulder fracture-dislocation and ipsilateral proximal humeral shaft fracture is not present in literature.

Li et al documented a case of posterior shoulder fracture-dislocation with distal humeral shaft fracture. At first, the surgical treatment option was the use of fixation devices (plate and screws) at the level of the

midshaft, disregarding the head of the humerus. Only later, one month after the first surgical treatment, an open surgery was performed to reduce the dislocation and, fortunately, the clinical outcomes at the one-year follow-up evaluation were satisfying, and the diagnostic assessments showed no signs of necrosis (1).

Furthermore, in literature, a few cases of posterior shoulder dislocation associated with ipsilateral humeral fracture are described. Good outcomes with closed surgery were obtained in the cases with an early diagnosis of dislocation, otherwise a secondary surgical procedure to repair the joint status resulted necessary (3, 5-10).

The critical aspect results in the precision and accuracy of the physical examination of the proximal and distal joints adjacent to the fracture, considering the fact that the dislocation can coexist in the presence of a fracture and that is not always detected with the first-line diagnostic assessments (1, 7).

The presence of fractures at the level of the humeral shaft can determine potential underestimation and diagnostic mistakes since the operator of the clinical and diagnostic assessments is more focused on these fractures, disregarding other possible surrounding joint lesions less evident in the conventional radiological diagnostic study.

Therefore, the physical examination results extremely fundamental; in this case the evaluation of the local swelling at the level of the posterior deltoid, proximal to the shaft fracture.

Other signs to evaluate wisely are the reduction of the protuberance of the head of the humerus anteriorly under the acromion, and the increase of the protuberance of the coracoid (typical of the posterior shoulder dislocation) although not always present (1).

However, considering the difficulty of the physical examination often performed in a limited timeframe, in patients with multiple traumatic injuries and poorly cooperative; the evaluation and the interpretation of the diagnostic assessment plays inevitably a fundamental role.

Unfortunately, it is not always possible to perform the correct axillary plane in the radiological images performed at the time of the hospitalization and the scarcely accurate evaluation of the images, combined with a fast physical examination, can lead the surgeon to inappropriate decisions regarding the surgical treatment and fixation device, with severe clinical consequences and healthcare legal implications.

In our case studies, the additional diagnostic assessment performed in the operating room (Case No. 1) and the CT Scan study (Case No. 2) were fundamental to obtain the correct examination of the lesions and, thus, to perform the proper surgical procedure. The follow-up evaluations showed evidence of radiological improvement and clinical recovery with good clinical outcomes, considering the entity of the fracture and the surgical treatment with plate and screws.

Conclusions

The accuracy of the physical examination and of the diagnostic assessment is fundamental for the diagnosis and the adequate treatment of these lesions since they are extremely rare and therefore difficult to be detected. Hence, we recommend performing a preoperative CT Scan study in case of uncertainty or in the presence of suspected clinical findings, in order to resolve those type of insidious clinical pictures.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Locked posterior fracture-dislocation of the shoulder

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Summary. *Background and aim of the work:* To describe a valid option for the treatment of locked posterior fracture-dislocation of the shoulder (LPFDS) and to compare it to the literature about this topic. *Methods:* We present a small case series (3 patients), with a medium follow up at 4 years and 5 months. We accurately describe our surgical strategies, underlining the choice of approach, reduction and fixation. *Results:* The three patients showed excellent functional and radiological results at the follow up examinations, with a full range of shoulder movements and complete regain of pre-trauma activities. A lateral approach (standard or minimally invasive), a reduction technique with a Shantz pin in the head and in the humeral shaft, and fixation with a locking plate were used in the three patients. *Conclusion:* LPFDS is a challenging lesion, hard to recognize and to treat. Our suggested method of treatment is highly reproducible and has revealed itself to be very effective in achieving good results. (www.actabiomedica.it)

Key words: locked posterior fracture-dislocation of the shoulder (LPFDS), trans-deltoid lateral approach, Shantz pins, locking plate

Introduction

Posterior dislocation of the shoulder is not common, representing between 3% and 5% of all shoulder dislocations (1, 2). 1% of shoulder dislocations involve a fracture, with an incidence estimated at 0.6 in 100,000 per year (3-6), but only 0.9% of the 1500 cases reported by Neer concerned posterior fracture dislocations (7, 8).

The mechanisms that cause posterior shoulder dislocation can be classified in two main groups: atramautic (forced muscle contractions during epileptic seizures, electric shock or electroconvulsive therapy) and traumatic (high energy trauma such as motor vehicle accidents, where the injury consists in axial loading of the arm in an adducted, flexed, and internally rotated position) (9).

In a posterior dislocation, the anatomo-pathologic findings can consist in a pure capsulo-labral lesion eventually associated to an impacted fracture of the humeral head (revers Hills-Sachs). In some cases, the lesion is complicated by a fracture of the proximal humerus, usually at the level of the anatomic neck. This fracture is defined "complex" by some authors (10), or locked posterior fracture-dislocation of the shoulder (LPFDS) by others, with the latter term indicating the complexity of the bone lesion (that can be two, three or four parts fracture sec. Neer classification) and the difficulty of the treatment of this injury.

LPFDS (as other posterior shoulder dislocations) can be easily missed; up to 79% of missed diagnoses are given in some reports (11) if a proper x-ray and CT scan investigation are not performed in the acute setting. As a matter of fact, the impossibility in patients with a proximal humeral fracture to obtain an axillary view of the shoulder can strongly underestimate the real pattern of this lesion (4). A physical examination of the patient is extremely useful, demonstrating a locked internally rotated shoulder with the impossibility of external rotation and elevation; the pain caused by minimal

mobilization can be an obstacle to an accurate examination. In case of missed diagnosis - "neglected" (within three weeks) or "chronic posterior fracture-dislocation" (after three weeks) -, the possibility of a proper open reduction and internal fixation could be impossible due to the vascular impairment of the humeral head and to the reabsorption of the tuberosities. Thus, the only possible treatment can be joint replacement.

There are some x-ray signs that can give suspicion to a posterior dislocation. A conventional anterior-posterior (AP) view of the shoulder shows an overlapping halfmoon appearance because of the intersection of the head and glenoid; but this peculiar sign can be lacking in LPFDS because of the head-splitting fracture-dislocation (12). Another sign that can be noticed is the lightbulb sign, which refers to the abnormal AP radiologic appearance of the humeral head in posterior shoulder dislocation (11). Perhaps the most characteristic radiologic sign of LPFDS is the double shadow line sign: it indicates the posterior dislocation of the shoulder with head-splitting fracture of the head (13). If LPFDS is diagnosed, or even suspected, a CT scan is recommended to better understand the bony anatomy and to properly plan the operation. Axial cuts and 3D reconstruction are particularly helpful to show the rate of involvement of the articular surface of the humerus. MRI is not considered useful before the operation.

Meanwhile, in cases of a posterior dislocation with an impaction fracture, on axial cuts of the CT scan one can have a suspicion of an engaging lesion. In cases of fracture dislocation, it is impossible to know before reduction of the head if the lesion is at risk of engaging.

In cases of posterior dislocation of the shoulder with a reverse Hill-Sachs lesion, the treatment options are well known and described: disimpaction of the fracture with lesser tubercle transfer, reconstruction with allograft or filling of the defect with bone substitutes. These options depends on the amount of impaction (14, 15).

Arthroplasty is preferred in cases in which 50% or more of the articular surface is affected. In cases of LPFDS there is not a gold standard treatment: the surgery can vary from reduction and pinning to open reduction and internal fixation to replacement arthroplasty. In the choice of open reduction and internal fixation, even the surgical approach is a matter of debate and it can sometimes be the first problem for the surgeon.

Robinson (10) was the first to accurately describe this lesion, which had been misdiagnosed or confused with other shoulder injuries in previous literature. He noted that, in the past, this fracture-dislocation was treated prevalently with a replacement arthroplasty of the humeral head, considering its high risk of avascular necrosis (16). However, the literature has shown that this complication is less frequent than previously thought and the poor outcomes of arthroplasty in these lesions has led to a more conservative treatment of this injury. Thus reduction and fixation of this fracture dislocation has become the preferred method of treatment, aiming to maintain the integrity and the vitality of the humeral head (3, 17-19).

We present a small case series, emphasizing our choice of approach, reduction manoeuvres and fixation strategies of this injury.

Case series

We analysed 3 patients who underwent surgery in our department.

Gender, age, side, type of fracture according to the Neer classification and mechanism of injury are shown in table 1.

All the patients were treated by two experienced trauma surgeons (L.B.V. and S.L.) using the same surgical approach, the same reduction strategies and the same hardware (Philos plate, DePuy Synthes, Johnson & Johnson, Oberdorf, Switzerland), which will be described later.

In the post-operative period we avoided immobilisation of the joint, inviting the patient to immediately start with gentle movements of the shoulder and active mobilization of their elbow, wrist and hand. The wounds healed uneventfully and stitches were removed 2 weeks after surgery. The active therapy started after 3 weeks, usually 3 days a week under the supervision of a physiotherapist.

The patients were evaluated at 1, 3 and 6 months after discharge, with a clinical examination and an x-ray of the shoulder. After the first check-up (1 month) the patients were invited to increase the load of physi-

Table 1. Series of 3 patients treated. Characteristics of patients, fracture and scores at follow-up

Patient and sex	Age	Side	Neer classification	Mechanism of injury	Day of surgery from the admission date	Tiem of follow-up	Quickdash score	Constant score
G.F., male (Fig. 1)	42	Right	2 parts	Bicycle	Same day	4 years and 6 months	12	100
G.M., male (Fig. 2)	44	Right	2 parts	Motorbike	1	4 years and 5 months	11	100
T.D., male (Fig. 3)	68	Right	3 parts	Bicycle	2	4 years and 4 months	13	95

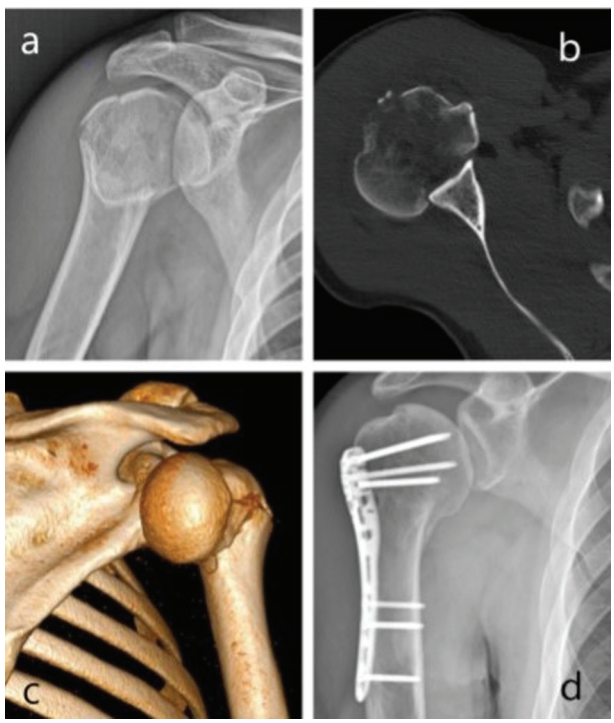

Figure 1. Imaging of patient G.F.: x-ray after trauma (a), axial ct of the fracture (b), 3d reconstruction of the fracture-dislocation (c), x-ray at follow-up (d)

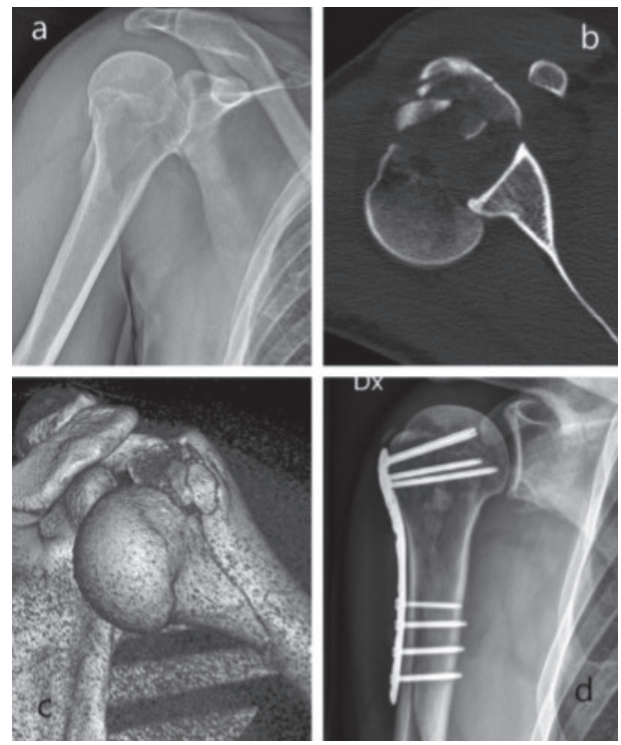

Figure 2. Imaging of patient G.M.: x-ray after trauma (a), axial ct of the fracture (b), 3d reconstruction of the fracture-dislocation (c), x-ray at follow-up (d)

otherapy and to slow down with the exercises only in case of pain.

The three patients were available at the follow-up call (average interval of 4 years and 5 months).

They were evaluated with the Quick Dash score and with the Constant score (table 1) and with an x-ray of the shoulder. The clinical results were surprisingly excellent despite the severity of the initial injury. The medium Quick Dash score was 12 (maximum 11) and the medium Constant score was 98.3 (maximum 100).

In the x-ray examinations, all the fractures showed complete healing with regained anatomical relationship between the head and the tuberosities. None of them had radiological signs of head necrosis or glenohumeral arthritis.

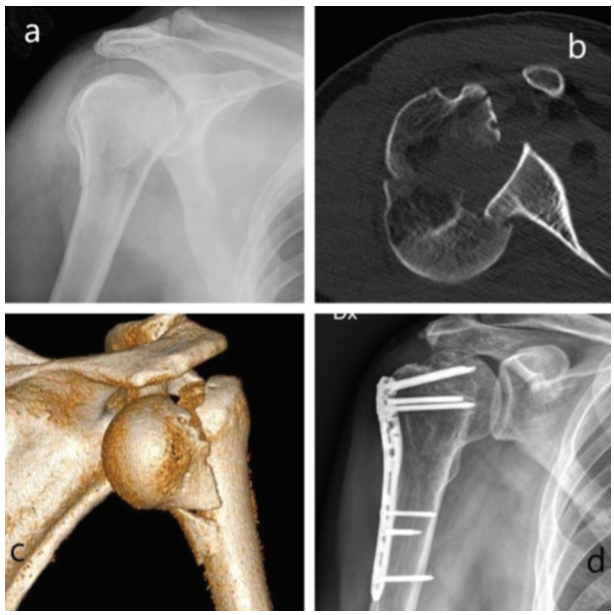

Figure 3. Imaging of patient T.D.: x-ray after trauma (a), axial ct of the fracture (b), 3d reconstruction of the fracture-dislocation (c), x-ray at follow-up (d)

All the patients sustained to have regained complete functionality of their shoulder, without any limitations of their work, sport and recreational activities. They confirmed that they were very satisfied. At the follow-up examination, one of the patients (G.M.), revealed a hypotrophy of the anterior third of the deltoid. This was perhaps due to a partial lesion of some fibres of the axillary nerve. This problem had never given any problems to the patient during daily work or leisure activities. Two patients (G.F. and T.D.) returned to work (office work) at about 5 weeks after surgery. The other (G.M., metal-worker) after 9 weeks. One of the patients (G.M.) restarted his favourite sport (cross motor biking) 40 days after surgery, despite this activity being discouraged by the examining physician at the first follow-up. The other two began their sporting activities (cycling) again at about 8 weeks from trauma.

Surgical approach

The choice of the approach is, in the Authors' opinion, the most important variable when addressing LPFDS. The approach must allow both the manipulation and the reduction of the dislocated humeral head as well as the fixation of the fracture.

In previous literature, the problem of the approach has been raised many times and different strategies have been used to handle this injury (10, 20-22). The deltopectoral approach has been widely used in shoulder surgery. It is useful in nearly all fractures of the proximal humerus and is mandatory in case of anterior fracture-dislocation of the shoulder. In LPFDS, the head lies behind the glenoid or the neck of the scapula and typically the upper arm is shortened because of the proximalization of meta-diaphysis of the humerus; the lesser tuberosity is frequently intact and the tendon of the subscapularis interferes with the access to the humeral head. Therefore, it would very challenging, if not impossible, from an anterior approach, to reach the humeral head without the tenotomy of the subscapularis at its origin.

Gokkus (12) proposed a modification of the deltopectoral approach, with subperiostal detachment of supraspinatus and subscapularis from their humeral origin. This exposure allows wide access to the joint and to humeral head. The Authors describe good results at the 1-year follow up. This strategy surely allows extensive access to the proximal humerus but it expects a post-operative loss of time to start physical treatment and rehabilitation, time which is necessary to allow the healing of the detached tendons. Furthermore, avoiding the release of tendons' insertions is usually recommended during any surgical approach.

Stableforth (20), in 1992, realized the difficulty in treating this lesion with a standard anterior approach. He therefore proposed the use of a "superior subacromial approach", which is the extension of the Author's approach for rotator cuff surgery. He extended the deep incision in a transversal plane, from 3 cm medial to the acromion-clavicular joint to 4 cm distal to the edge of the acromion. After detaching subperiostally the deltoid origin from the anterior acromion, he reached the humeral head with the incision of the supraspinatus tendon 5 mm behind the cuff interval. This approach only allows the fixation of the epiphysis of the humerus and it did not describe the distal extension necessary for the fixation of the fracture with plate and screws.

Fiorentino (21) suggests a double approach. Firstly, a straight posterior approach through the deltoid fibres, developing the space between infraspinatus and teres minor. In their experience, with this ap-

proach, the humeral head can easily be reduced with gentle manual pressure. Then, a standard deltopectoral approach is carried out to fix the fracture with plate and screws.

Robinson (10), in his 26-case series, describes a shoulder-strap skin incision and a modified deltoid-splitting surgical approach with identification and protection of the axillary nerve when it traverses the distal extent of the incision. A similar approach was then described by Shin who uses a straight lateral incision with protection and mobilization of the axillary nerve (23).

In our experience, and according to other authors (10), the key factor in facilitating the relocation of the humeral head is a lateral approach. The standard transdeltoid lateral approach (Fig. 4), with distal extension and isolation of the axillary nerve or its variant with two incisions for minimally invasive plate osteosynthesis, has been widely used for proximal humerus fractures and it is extremely useful in LPFDS. Indeed, with this approach, the humeral head can be palpated and manipulated permitting the reduction of the dislocation. Furthermore, the lateral approach allows the standard fixation with plate and screws of the proximal humerus without adding other incisions and, most importantly, without detaching muscular insertion. Robinson (10) adds an arthrotomy through the rotator cuff interval to assess the extent of the reverse Hill-Sachs and, consequently, to treat this adjunctive lesion with elevation of the osteo-chondral impaction and bone packing of the defect. In our series, this adjunctive exposure has never been done because, after reduction and fixation of the fracture, not any of the shoulders resulted in having an engaging revers Hill-Sachs. In fact, the passive range of movement of the shoulders was completely free in all the three cases.

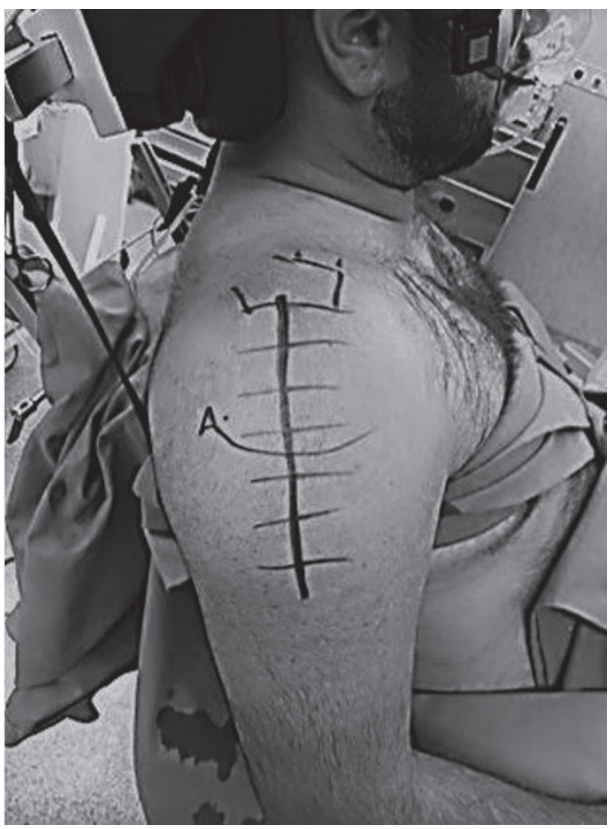

Figure 4. drawing of skin incision, with expected position of the axillary nerve (letter A)

Reduction technique of the fracture-dislocation

The literature on LPFDS rarely mentions the opportunity to attempt a closed reduction; with this attempt being unsuccessful in the cases reported (10, 12). We do not recommend trying this manoeuvre. First of all, because a locked posterior humeral head is virtually impossible to mobilize and relocate only by traction and rotation and then there is the high risk of further damage to the dislocated epiphysis.

The first surgical step in LPFDS is to disengage the humeral head from the posterior margin of the glenoid. Every attempt has to be made to avoid any further injury to the joint surface and to the vascularization of the epiphysis.

Even if some authors describe an easy reduction only by pushing the humeral head with their fingers in a postero-anterior direction (21), in practical experience this manoeuvre is rarely (or exceptionally) successful. In our cases, we could not get the reduction only with our fingers because of the strong lock of the head between the bone and the swollen posterior capsule, muscles and soft tissues.

The use of a sharp or a smooth Hohmann retractor, placed just posteriorly to the humeral head and pushed anteriorly acting as a lever, is an option as a reduction tool (12); this procedure needs gentle handling of the soft tissues behind the dislocated humeral head because there is high risk of further damage to

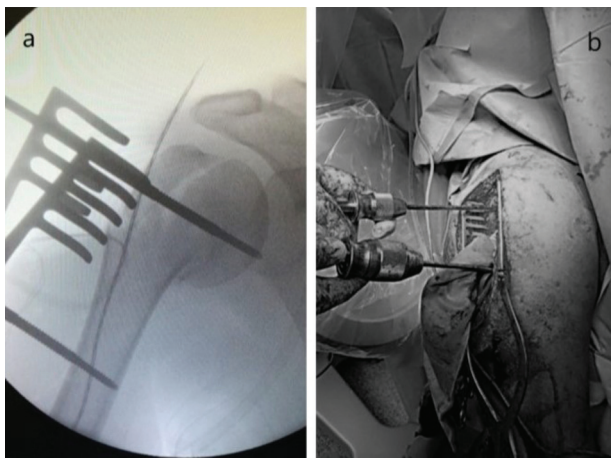

Figure 5. Reduction technique with Shantz pins (a- fluoro imaging; b- clinical picture)

the muscles of the rotator cuff (infraspinatus and teres minor) and to the posterior capsule. In our series, we did only one attempt with a smooth Hohmann in the first case but it failed therefore we decided to abandon this step in the subsequent cases.

The metaphysis and the humeral shaft need to be mobilised laterally and distally, to give space to allow the reduction of the humeral head. Then, the humeral head has to be gently pushed in place after a slight external rotation to disengage it from the border of the glenoid. We obtained this with the use of two Shantz pins acting as joysticks (Fig. 5); one in the head and one in the shaft of the humerus. This technique was also described by Sadaat through a deltopectoral approach with the use of only the pin in the head (22). There is the risk of perforation of the articular surface with the head Shantz screw but the damage caused by the tip of the pin is deemed insignificant.

Once the head is relocated, the reduction to the humerus can be done with clamps (Weber or similar) (Fig. 6) and provisionally secured with Kirschner wire. In case of fracture of the tuberosities, they can be loaded on suture or can be directly reduced and fixed with K wires too, as in a simple fracture of the proximal humerus.

Osteosynthesis

In the first reports, the fixation consisted only of single compression screws directed from the lateral wall of the humerus or from the tuberosities toward

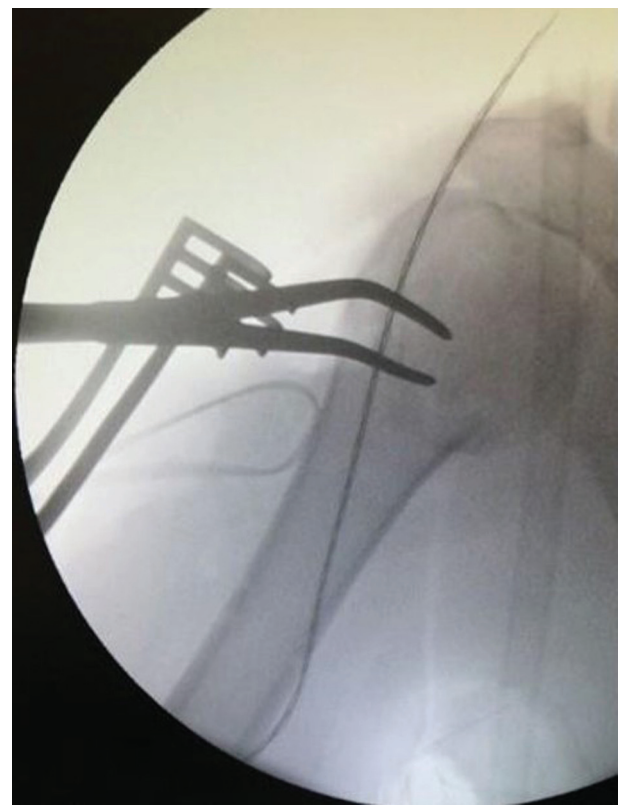

Figure 6. Provisional reduction with a Weber clamp

the humeral head (20). This osteosynthesis requests a post-operative period of immobilization, with consequent risk of articular stiffness, and has also revealed many failures due to lack of resistance to pull-out. A stronger construct can be obtained with a formal internal fixation with plate and screws.

Traditional plates have been used for several years in proximal humerus, demonstrating good results. Their use in osteoporotic bone and in comminuted fractures has revealed the limits of traditional plates (24). Angular stability has completely changed the approach to many fractures, especially in the metaepiphyseal ones (Fig. 7). Over the past decade, locking plates have been shown to be biomechanically superior to standard non-locking plates in terms of stability and resistance to pull-out, both in normal and in osteoporotic bone (25, 26). The design of the proximal locking plate has progressively changed and improved during the years, especially the direction of the epiphyseal screws. With the proximal screws, the humeral head can be fully filled by hardware.

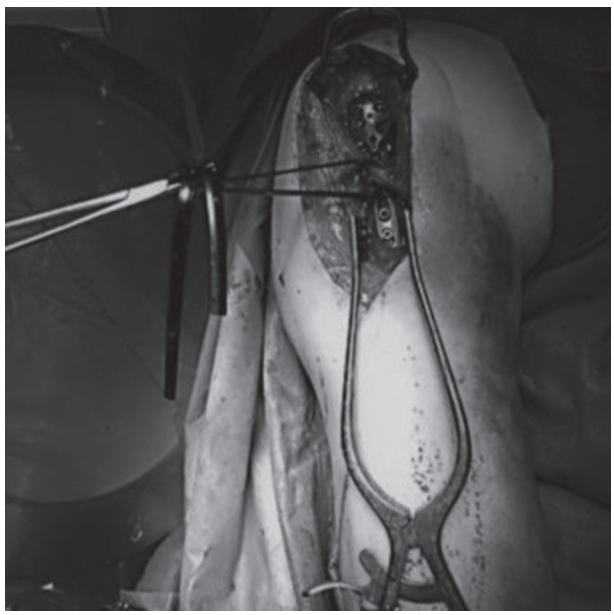

Figure 7. Final picture of internal fixation with a locking plate via a trans-deltoid lateral approach with isolation of the axillary nerve

In previous literature, other hardware for fixation of LPFDS such as proximal humeral nails have not been mentioned.

Replacement arthroplasty, widely used in chronic LPFDS, is an option even in acute lesions, especially if 50% or more of the articular surface is affected (27). On the other hand, as mentioned before, the fair results of substitution in these injuries has led to a more conservative attitude when deemed feasible. The Authors' opinion is that arthroplasty can be a salvage option in cases of failure of the osteosynthesis (avascular necrosis, degenerative arthritis or non-union).

The operation should be conducted as soon as possible; it does not mean that this lesion has to be operated in an emergency/urgency setting but our preference goes to operate within 24-48 hours. With this strategy, the shoulder is not already too swollen and the reduction can be easier, without muscle contracture. Obviously, this is better for the patient, avoiding discomfort and prolonged use of painkillers.

Post-operative treatment and rehabilitation

It is well known that, after surgical treatment of a proximal humeral fracture, the key point is the early start of movement and rehabilitation to avoid capsular contracture and consequent shoulder stiffness. A passive range of movements with a therapist, auto-assisted or with mechanical devices is encouraged from the very early post-operative period, as tolerated by the pain. The assumption of early rehabilitation is based on an adequate analgesic therapy, i.v. or i.m. the first days and per os after hospital discharge. Paracetamol or opioids are preferred to nsaids for better tolerance and less side effects.

An active range of movements can be started 3 weeks after the operation, after the so called fibrous callus have formed. In cases of involvement of the tuberosities, active movement can be delayed to the 4th or the 5th week after surgery.

For our patients, passive rehabilitation started 24-48 hours after surgery. A sling was prescribed only for patient comfort. Self-assisted exercises of pendulum and oscillations of the shoulder and active flexion and extension of the elbow were shown and immediately begun after drain removal. The addition of other exercises, self-assisted by the healthy arm, were encouraged 2-3 times a day and assisted kinesiotherapy was prescribed. After 3 weeks the patients were allowed to start gentle active movements, under the supervision of a rehabilitation therapist.

Conclusions

LPFDS is a rare entity and the literature reports only a small series of cases.

There is a high risk of overlooking this injury but some radiologic signs can pose strong suspicions of this lesion. Surgical treatment is recommended, with open reduction and internal fixation preferred in acute cases. Many approaches and reduction manoeuvres have been described in medical literature without gaining definitive agreement on the surgical strategies to be taken.

The encouraging results of our series led us to strongly recommend the lateral approach and the reduction steps as described. First of all thanks to the relative simplicity of them and then because these techniques are very respectful to the biology of the proximal humerus.

Finally, as fixation with a locked plate in proximal humerus is gaining more and more agreement, it has to be considered the gold standard in LPFDS.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Transposition of the Extensor Indicis Proprius (EIP) for inveterate post-traumatic rupture of the Extensor Pollicis Longus (EPL) of the hand. 12 clinical cases

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Summary. *Background and aim of work*: Subcutaneous tendon rupture of the Extensor Pollicis Longus (EPL) is one of the most frequent injuries of the extensor tendons of the hand. In this paper, we report our experience on 12 cases of atraumatic subcutaneous EPL lesions treated in our hospital with Extensor Indicis Proprius (EIP) transposition. *Methods*: This observational study was conducted between January 2015 and December 2018 in the Casa di Cura "Prof. Nobili", Castiglione dei Pepoli (Bologna). Twelve patients were included in the study, nine of whom were females and three were males, with an average age of 72 years (range: 40-84 aa). The average follow-up was 32.4 months. The preoperative diagnosis was subcutaneous atraumatic rupture of the EPL tendon in all cases. *Results*: The clinical outcome was excellent in all the patients at the end of follow-up. At the second clinical control, all patients achieved complete active extension of the distal phalanx of the first finger. We did not notice any intra- or extra-operative complications, and the post-operative course was regular in all cases. *Conclusion*: EIP transposition has allowed an almost complete recovery of the ability to extend the first finger in patients treated in our hospital, in line with what is described in the literature. In addition, patients' satisfaction rate was excellent in all cases. Based on the good results and the low rate of complications affecting the donor area, we consider EIP transposition surgery to be a valid option for inveterate EPL ruptures. (www.actabiomedica.it)

Key words: extensor tendon, rupture, transposition, hand injuries

Background

Subcutaneous tendon rupture of Extensor Pollicis Longus (EPL) is one of the most frequent injuries of the extensor tendons of the hand. This type of lesion can be the direct consequence of violent traumas to the wrist, but more frequently occurs secondary to degenerative or inflammatory diseases, rheumatism, or after consolidation processes involving distal fractures of the radius. Sometimes, this happens without a predisposing condition, simply due to continuous use of the I finger in flexo-extension movements.

The rupture of the EPL usually occurs at its point of reflection on Lister's tubercle, where frictions are greatest and vascularisation is less represented (1). The continuous repetition of microtraumas in the area of reflection of the tendon on Lister's tubercle can over time lead to its subcutaneous rupture.

Some authors have hypothesised the pathogenetic mechanisms behind this lesion. Among these, Engkvist and Lundborg (2) considered that the appearance of a hematoma formed inside the tendon sheath as a result of trauma or inflammation of the wrist usually led to an increase in pressure in an inelastic compartment. Increases in pressure can cause alterations in blood supply and can result in necrosis and rupture of the tendon structure (2). In the period following tearing of the EPL tendon, a retraction of the proximal stump is generally observed, accompanied by degenerative processes that compromise the direct repair.

Clinically, it is characterised by the impossibility of active extension of the first ray interphalangeal joint. Rarely the patient could experience a sensation of detachment accompanied with discomfort coming from the dorsal zone of the first ray during a particular hand action. Usually, however, the patient does not feel any pain and often realises after a few days that he has limitations in the use of the first finger.

The diagnosis is clinical and the most appropriate first-level examination is ultrasound of the extensor apparatus of the first ray. Radiography and MRI of the wrist, however, can help detect osteophytosis secondary to vicious consolidations which may be responsible for tendon rupture.

Many treatments have been suggested, including tendon grafting using Palmaris Longus (3), arthrodesis of the IF of the thumb, or a tendon transposition technique using the Extensor Indicis Proprius (EIP) developed by Mensch in 1925 and then used by many authors also utilising the Extensor Carpi Radialis Longus (ECRL), the Extensor Proprius of the V finger, or the II tendon of the Extensor Digitorum Communis (EDC II). In this paper we report our experience on 12 cases of atraumatic subcutaneous EPL lesions treated in our structure with transposition of the EIP.

Methods

This observational study was conducted between January 2015 and December 2018 in the Casa di Cura "Prof. Nobili", a private hospital accredited to the National Health System and located in Castiglione dei Pepoli (Bologna). Twelve patients were included with an average age of 72 years (range: 40-84 aa); nine patients were females and three were males. The intervention was conducted on the right hand in eight patients and on the left hand in four patients. The dominant limb was the right in 10 patients and the left in two. 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.

All the patients were evaluated in the 30th, 75th, and 150th day with clinical control, followed each subsequent year with a telephone interview, per the follow-up protocol adopted in our facility. The average follow-up was 32.4 months.

The preoperative diagnosis was subcutaneous atraumatic rupture of the EPL tendon in all cases. For all cases, a wrist trauma (distortion or fracture) had occurred and no rheumatic or inflammatory pathologies were recorded in the patient's history.

On clinical examination, all the patients presented the inability to extend the distal phalanx of the first finger with the palm of the hand resting on a plane; the absence of retropulsion is a distinctive sign of EPL lesion. In order to examine the quality of the extensor apparatus of the second finger, the isolated amount of extension was measured starting from the maximum active flexion. We then evaluated the ability to lift the second finger with the palm of the hand placed on a plane.

For the assessment of post-operative results, we analysed the strength and the articular extension of the first finger, the degrees of movement on the various planes, the ability to regain normal daily activities, and patient satisfaction. All values were compared with the healthy contralateral limb before and after surgery.

In relation to individual parameters, we considered the result to be excellent if the strength and articulation of the first finger were comparable to the opposite side, good if only modest limitations against passive resistance were present, mediocre when these limitations occurred with little or no resistance, and very bad in case of complete deficit.

Surgical technique

Under plexus anaesthesia, a dorsal incision at the first ray of the affected hand was made. Proceeding in-depth through the tissue planes, the distal stump of the EPL was found and isolated from the surrounding soft tissues, highlighting its complete detachment from the proximal portion. A dorsal incision was then made in correspondence of the second ray of the same hand to identify the EIP tendon, which was isolated and dissected at the level of the metacarpal head. The distal stump was sutured to the EDC at the second ray, while the proximal stump, after being freed from the surrounding soft tissues, was transported through a subcutaneous tunnel at the level of the first ray and then sutured to the distal abutment of the EPL (Fig. 1-4). During tenorrhaphy, it is very important to test

the tension of the construct. After careful haemostasis, the planes were sutured and an extension position splint was put in place and maintained for 30 days.

After this period, the splint was removed and the active extension of the distal phalanx was directly evaluated. In addition, a static and dynamic ultrasound was performed. Following these evaluations, physical and re-educational therapies were performed in order to achieve the recovery of the complete extension of the first ray, the force of gripping, and the opposition of the thumb.

Results

The clinical outcome was excellent in all the patients. Immediately after the removal of the splint, all 12 patients were able to extend the last phalanx of the first finger a few degrees and could actively extend the index without any deficit (Fig. 5-6). The ultrasound evaluations showed the proper continuity of the tenorrhaphy and its correct sliding through soft tissue.

At the second clinical control, all the patients achieved complete active extension of the distal phalanx of the first finger.

We did not notice any intra- or extra-operative complications and the post-operative course was regular in all cases. At the strength tests administered during follow-up, all 12 patients showed a clinical picture comparable to the healthy contralateral limb.

Discussion

In case of inveterate rupture of the EPL, direct suturing of the proximal stump to the distal abutment

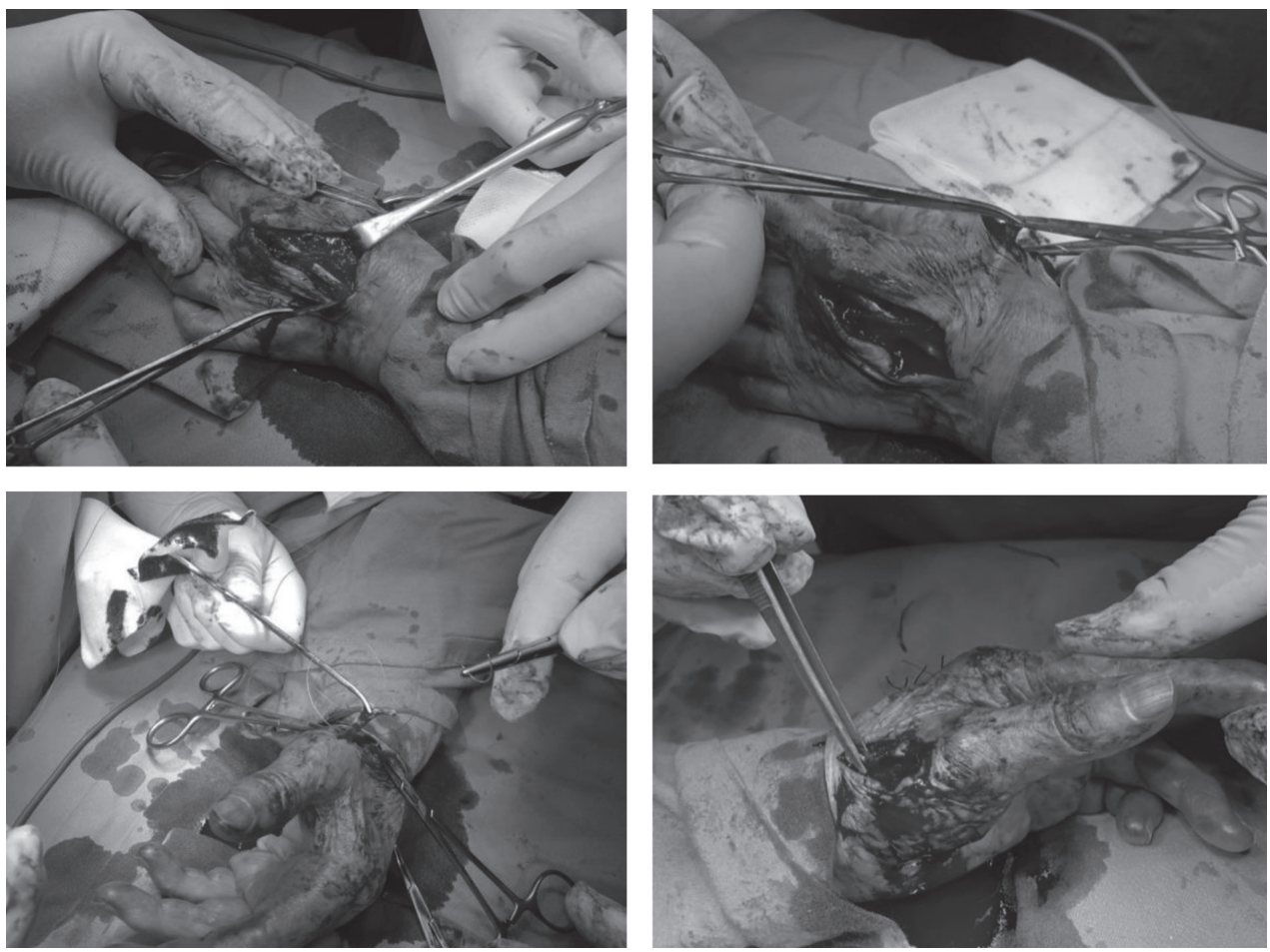

Figure 1-4. Procedure of transposition of EIP pro EPL. The details are set out in the text

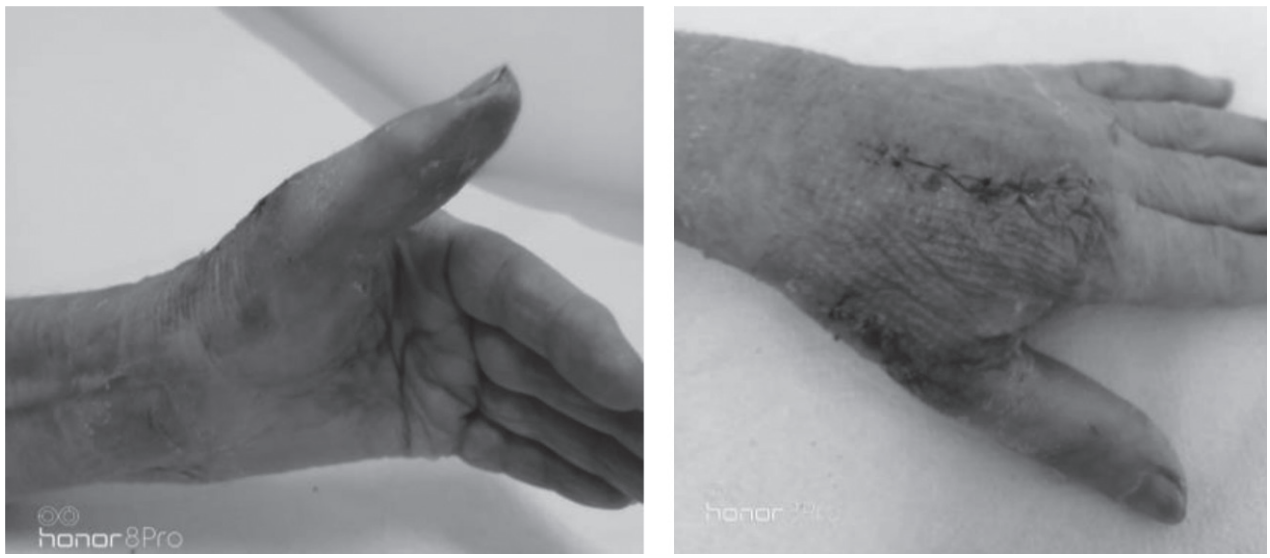

Figure 5-6. Clinical check 30 days after surgery

is not a viable and reproducible option, due to the degenerative processes that are often observed following such rupture (4-5). In addition, it should be noted that any suture would occur at the point of reflection of the tendon on the radial tubercle, possibly compromising the mechanical seal. Lesion repair using tendon grafts, such as the Palmaris Longus (6,7), has been progressively abandoned because of the need to perform multiple skin incisions and a double tendon suture.

For these reasons, tendon transposition surgery is currently providing the best results and is supported by a higher number of good results. In the past, several variants of tendon transfer have been tested, but most have shown important limitations. The transposition of the Extensor Proprius of the V finger proposed by Verdan did not allow a good sliding of the transposed tendon and a sufficient extension force of the first ray (8). The procedure using the Extensor Carpi Radialis Longus (ECRL) gave good results (9, 10), even if it was supported by a smaller number of cases.

According to most authors, the tendon that provides the best outcome in terms of distal phalanx extension in the EPL repairing is the Extensor Indicis Proprius (EIP) (11-15). This method has favoured an almost complete recovery of the ability to extend the first finger in patients treated in our hospital, in line with what is described in the literature (11-13). Moreover, patients' satisfaction rate was excellent in all cases.

Since this tendon had to be transposed to improve the extension function of the first finger, it was discussed whether this intervention could reduce the extension capacity of the second ray (17,18). Matter-Parrat showed a certain decrease of the independent extension force of the second finger and a reduction of the ROM in active extension of the II MCP following the transposition (17). Despite these findings, any deficit in the performance of normal daily activities was considered derisory (17). On the contrary, in the series of Russel Moore et al. (16) and Kitano et al. (19), no deficit in strength or ability to separately extend the index was observed. In our case study we did not find any alterations involving independent extension and extension force of the second ray.

Conclusions

Based on the quality of the obtained results and the low rate of complications affecting the donor area, we consider EIP transposition surgery a valid option for inveterate EPL ruptures.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

The use of Carbon-Peek volar plate after distal radius osteotomy for Kienbock's Disease in a volleyball athlete: a case report

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Summary. Kienbock's Disease, or lunatomalacia, has uncertain etiopathogenesis, it is more common in male from 20 to 45-year-old. The Lichtman's classification is the most used by authors and it divides Kienbock's Disease in 4 stages according to radiographic parameters. In early stages could be performed a conservative treatment, but failure rate is high; various surgical techniques are available in case of failure or higher stages. We report a case of a 26-year-old female volleyball player affected by stage I Kienbock's Disease who underwent distal radius osteotomy core decompression synthesized with Carbon-Peek plate fixation. Follow-up was performed with clinical evaluation (ROM analysis, VAS score, Quick Dash Score), wrist radiographs and wrist MRI. (www.actabiomedica.it)

Key words: Kienbock, Carbon-Peek plate, volleyball, radius osteotomy, core decompression

Introduction

Kienbock's Disease has uncertain etiopathogenesis, it is probably caused by repeated wrist traumatism or a single acute episode (1, 2); it is more common in dominant hand of male from 20 to 45-year of age.

Lichtman classification divides Kienbock's Disease in 4 stages (3, 4):

- stage I: normal radiographs, changes on MRI;
- stage II: definite density changes in the lunate bone on x-ray images;
- stage IIIA: collapsed lunate without scaphoid rotation;
- stage IIIB: collapsed lunate with fixed scaphoid rotation;
- stage IV: pan carpal arthrosis.

A variety of surgical treatments are available (temporary scapho-trapezio-trapezoidal pinning, joint leveling procedure, arthroscopic core decompression (5), radial wedge osteotomy, vascularized bone graft, wrist fusion, etc.) after failure of conservative treatments (rest, NSAID, Corticosteroid injection, shock waves, etc). In case of young patients, a radius-carpal joint decompression performed with a shortening osteotomy of the distal radius can represent a valid choice of treatment. Carbon-Peek fixation devices are currently used in traumatology with good clinical and radiological results for the treatment of wrist and ankle fractures (6, 7); in particular for wrist fractures are available two kind of plates (standard plates or anatomic low-profile Carbon-Peek plates) (8).

We report a case of a 26-year-old female volleyball player affected by stage I Kienbock's Disease who underwent distal radius osteotomy core decompression with Carbon-Peek plate fixation. Follow-up was performed with clinical evaluation (ROM analysis, VAS score, Quick Dash Score), radiographs and MRI scan. To our knowledge, there are no studies in the literature regarding Kienbock's disease treated with Carbon-Peek fixation devices.

Case History

A 26-year-old female volleyball player presented with an increasing left wrist pain, swelling, tenderness and functional limitation without any efficient trauma. Conventional wrist radiographs displayed normal carpal bones and a negative ulnar variance. Wrist Magnetic Resonance Imaging (MRI) showed high signal intensity of the lunate on T2-weighted images and normal signal intensity on T1-weighted images (Fig. 1). These results are compatible with a diagnosis of stage I Kienbock's Disease according to Lichtman's classification (3, 4).

After 1 month of conservative treatment (rest and NSAID) with no results, surgical options were the following: distal radius core decompression, joint levelling procedure, revascularization procedures. Due to negative ulnar variance a surgical core decompression with distal radius shortening osteotomy associated with Carbon-Peek plate fixation was performed. The choice of Carbon-Peek plate was due to its radiolucency on radiographs and low intensity signal on MRI. The postoperative protocol included wrist immobilization with cast for 2 weeks and follow-up was performed with clinical and radiographical evaluation at 1 month follow-up and clinical, radiographical and MRI evaluation at 3 months follow-up. Pain relief was obtained at 3 weeks and complete consolidation of osteotomy was shown after 1 month on radiographs. Normal signal intensity on MRI T2-weighted images for lunate bone was shown at 3 months follow-up (Fig. 2).

Return to volleyball training was conceded after 3 months.

Clinical evaluation was performed with analysis of wrist range of motion (ROM), Visual Analogue Score (VAS) and Quick Dash Score at final follow-up. Results showed wrist flexion of 90 degrees, wrist extension of 85 degrees, ulnar deviation of 35 degrees, radial deviation of 20 degrees (Fig. 3). VAS score at follow-up was 0. Quick Dash Score result was 6.8%.

Discussion

Kienbock's Disease is difficult to diagnose in early stage and in these cases MRI T2-weighted images represent the gold standard for diagnosis. In early stages (I-II according to Lichtman's classification) associated with a negative ulnar variance, distal radius shortening osteotomy with plate fixation offers good clinical

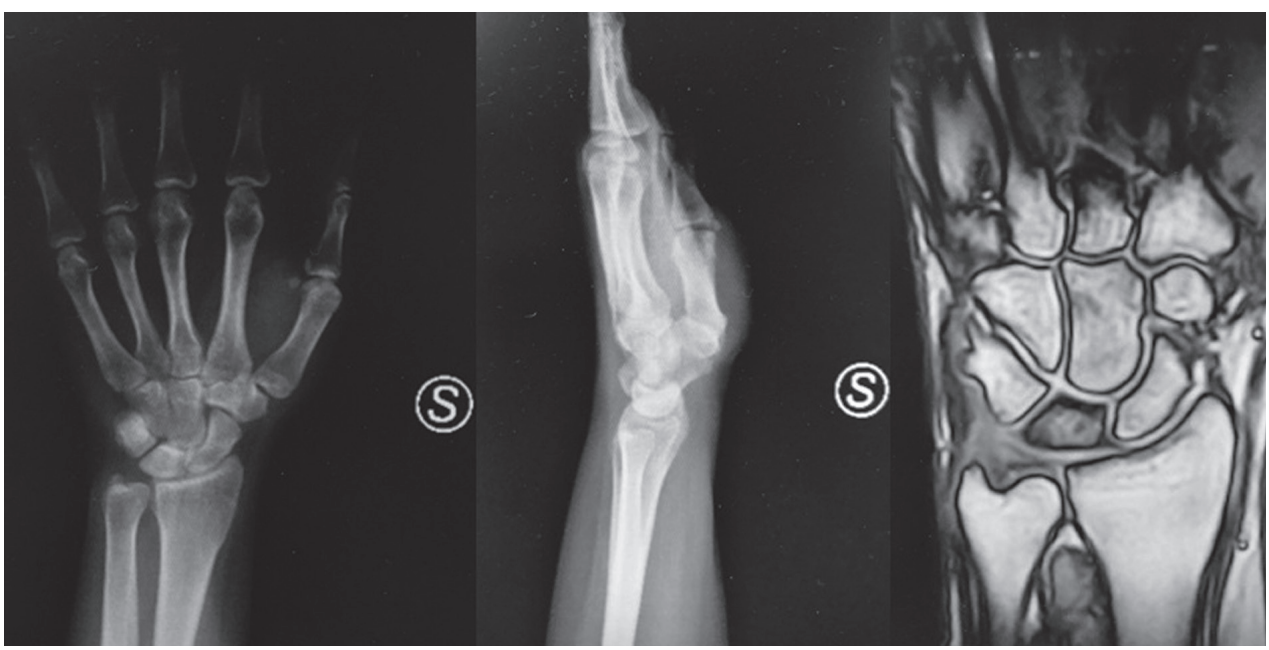

Figure 1. X-Ray and MRI images preoperative

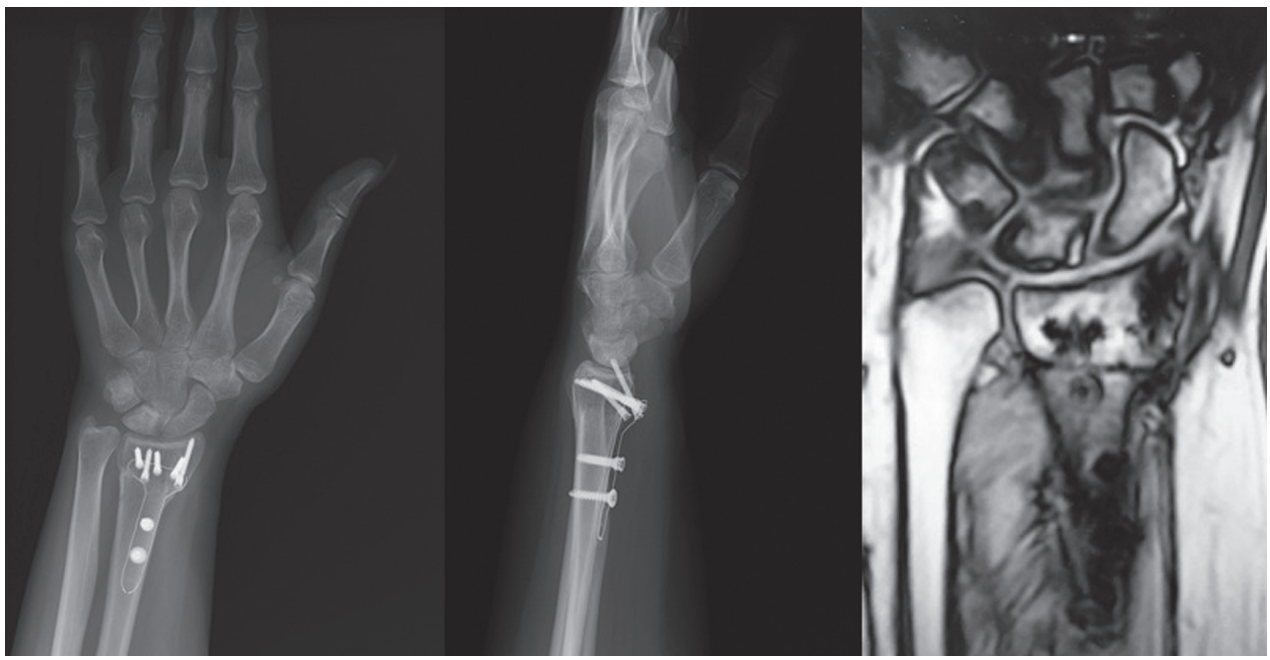

Figure 2. X-Ray and MRI images at 3 months follow-up

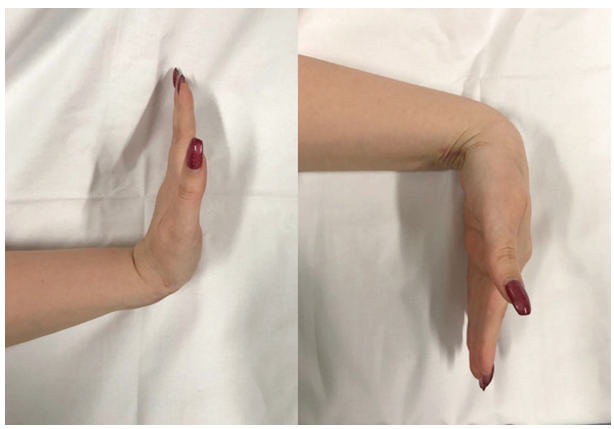

Figure 3. Wrist range of motion at 3 months follow-up

results in few weeks but using conventional stainless-steel radial plate will not permit good images at MRI follow-up. The great advantage of Carbon-Peek plate fixation devices is that guarantees low impact on MRI images quality allowing MRI follow-up until T2-weighted signal intensity normalization was obtained.

Carbon-Peek devices yield several advantages over traditional orthopaedic materials including radiolucency and low interference on MRI scans (9). Moreover, Carbon-Peek implants can be designed with tailored mechanical properties in order to give to the device appropriate strength, stiffness and toughness (10). Steinberg et al. reported similar biomechanical characteristics between Carbon-Peek and conventional devices (11).

In the literature there are many studies documenting good clinical performance of Carbon-Peek devices in spinal, orthopaedic and trauma surgery (6, 7, 12-15).

This case report suggests that Carbon-Peek plate fixation is a safe and advisable procedure after radius osteotomy for treatment of early stage Kienbock's disease due to its hypodensity on MRI scan.

Patient Declaration Statement: The authors certify that they have obtained all appropriate patient consent forms. In the form the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

The scapho-capitate syndrome: a case report with follow-up of three years

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Summary. The scapho-capitate or Fenton syndrome is characterized by an associate fracture of the scaphoid and capitate with rotation of 90° or 180° of the capitate's head. We report a case of this syndrome which occurred in a fifteen years old professional motorcyclist who came to our observation following a high-energy trauma that occurred during the track tests. Through a dorsal access the fractures of the capitate and scaphoid were reduced and stabilized with Kirschner wires. The patient was radiographically and clinically evaluated three years after surgery; complete healing of scaphoid fracture and reabsorption of the capitate's head as consequence of avascular necrosis with the onset of a midcarpal arthritis were observed. Despite this radiographic evolution, the patient achieved excellent clinical result featured by complete recovery of wrist motion and absence of pain thus allowing the return to motorcycling. (www.actabiomedica.it)

Key words: Fenton's syndrome, scapho-capitate syndrome, fracture, capitate, scaphoid, carpus, wrist

Introduction

Fracture-dislocations of the carpus represent a spectrum of complex injuries. In fact, accurate descriptions of specific injuries are often difficult.

The scapho-capitate syndrome was precisely described by Fenton and Rosen (1, 2) as associate fractures of the scaphoid and capitate with the rotation of the head of capitate of 90° or 180°, even if the first report of this injury was by Lorie (3) and Perves (4) in 1937.

It is a very rare lesion and the diagnosis can be difficult. Few cases have been reported in the literature (5-9) and it is often associated with high-energy traumas (10). In fact, capitate bone is not normally subject to fracture because it lies in central position in the carpus at the intersection of the longitudinal and transverse carpal arches (11). It is surrounded and reinforced by the other carpal bones (2) and by strong ligaments that anchor the body of the capitate to the trapezoid, hamate, and base of the third metacarpal, leaving the head and neck vulnerable to fractures (11).

Case report

We report the case of a young professional motorcyclist who came to our observation following a high-energy trauma that occurred during the track tests. At the time of the trauma he was 15 years old. An initial radiographic evaluation was performed which showed the fracture of the scaphoid and of the capitate with alteration of the radiographic Gilula arches. A CT scan was then performed to better study the fractures which showed, in addition to the fracture of the capitate, a 180 ° rotation of its head and the multi-fragmentation of the scaphoid (Fig. 1),

A single dorsal approach was used. The fracture of the capitate was reduced (Fig. 2) and stabilized with two Kirschner wires inserted from proximal to distal

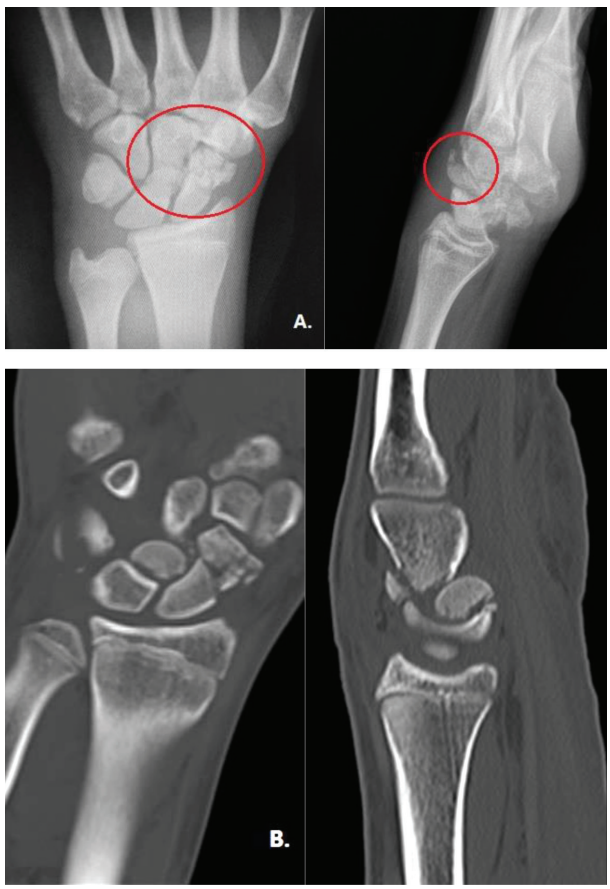

Figure 1. Preoperative standard radiographs (A) and CT scans (B) which show the fractures

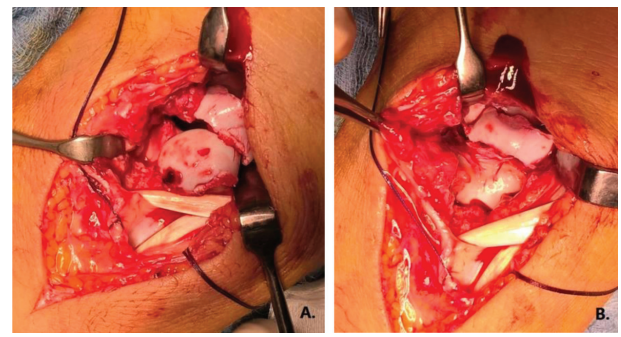

Figure 2. Intraoperative image before (A) and after reduction (B) of fracture of the capitate following a single dorsal approach

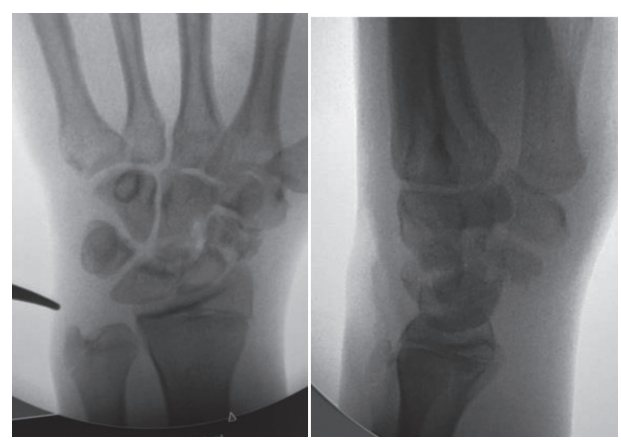

Figure 3. Intraoperative fluoroscopic images of fracture reduction

and one between capitate and hamate (Fig. 3 and 4). Since the scaphoid fracture was multifragmented, it was not possible to perform its synthesis with a Herbert-type headless screw, so the fixation was done with a Kirschner wire; a volar protective plaster cast was placed for 35 days. The patient also underwent pulsed magnetic fields in order to facilitate fractures healing.

After 35 days x-rays showed initial radiographic signs of healing of the scaphoid and initial reabsorption of the head of the capitatus without evidence of alteration of the arches of Gilula and articular collapse (Fig 5).

Kirschner wires were removed six weeks after surgery and the patient started physiotherapy for functional recovery with gradual improvement in the following weeks of wrist flexion and extension and ulnar and radial deviation. After two months of rehabilitation he resumed his competitive activity.

The patient was evaluated three years later. New radiographs showed complete healing of the scaphoid fracture and a complete reabsorption of the capitate's head caused by its avascular necrosis with the onset of a midcarpal osteoarthritis despite the good reduction obtained with surgery (Fig. 6). However, radiographs showed that the Gilula arches remaineed substantially intact, there was no joint collapse and functionally the radiocarpal joint was good with loss of only about 20° of dorsal flexion and about 10 ° of flexion of the radiocarpal joint.

Clinically the patient was satisfied and he did not report pain and is still continuing his competitive sports (Fig. 7).

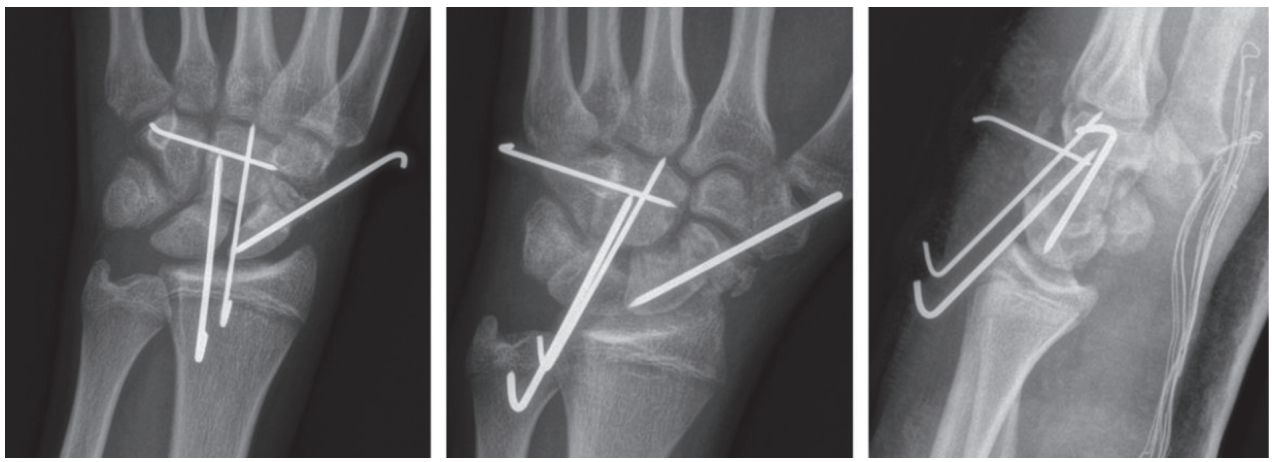

Figure 4. Postoperative x-ray views.

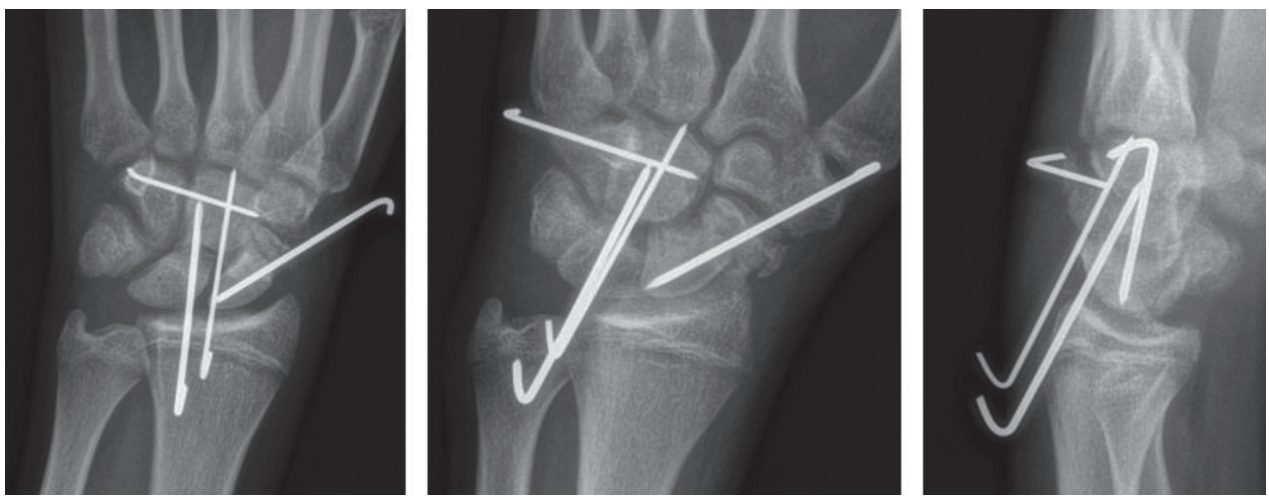

Figure 5. Radiographic images 35 days after surgery. An initial radiographic healing of the scaphoid and an initial reabsorption of the capitate's head can be noted

Discussion

The scapho-capitate syndrome is considered by many authors as a variety of trans-scaphoid, trans-capitate perilunar fracture-dislocation, and it represents the final stage of a greater arc injury which has either reduced spontaneously or by manipulation (12-14).

The mechanism of injury is not still clear. Fenton (2) first hypothesized that, during a fall, when the hand is in dorsiflexion position and radial deviation, the strength of the impact is transmitted from the radial styloid process through navicular onto the capitate. In fact, the fracture lines in the two bones seem running together without interruption.

Currently, the hypothesis proposed by Stein (15) is the most accredited. For him, the trans-scaphoid, trans-capitate perilunar fracture-dislocation occurs for a forced hyperextension of the wrist during a fall on the palm of the hand. It causes the fracture of scaphoid and this fracture allows a further hyperextension of the wrist so the capitate beats on the dorsal edge of radium and breaks. The continuation of the hyperextension movement involves a rotation of 90° of the capitate. When the wrist returns to neutral position, the head

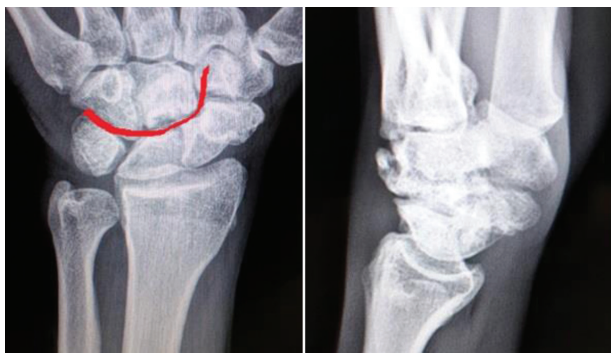

Figure 6. Radiographs three years after surgery with complete healing of scaphoid and reabsorption of the capitate's head; the Gilula arches remain substantially conserved, without joint collapse

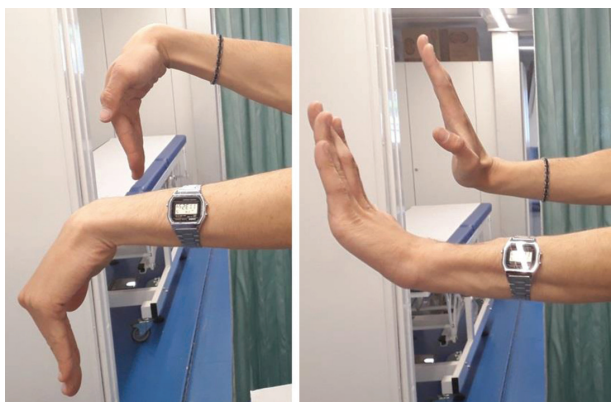

Figure 7. Clinical evaluation 3 years after surgery; good result

of capitate rotate another 90°. For Sukul and Johannes (16) two type of trans-scapho-transcapitate fracture dislocation can be recognised, one in which rotation of the capitate is limited or does not occur at all, and the other in which there is 180° of rotation of the capitate head; this implies that a dorsal perilunate dislocation was originally present during the injury followed by a spontaneous reduction (17).

This injury is often associated with other radial or ulnar wrist lesions not always clearly detectable on X-rays such as the rupture of scaphotrapezoid ligament and lunotriquetral ligament or fracture of trapezium, trapezoid, triquetrum or hamate. Finally, the type of injury depends on two factors: the direction of the force of the injury and the severity of the injury which determines how the three columns of the wrist are interested (18).

As consequence of its rarity, the diagnosis is not simple, and the fracture pattern may not be correctly detected. It is necessary to take the correct antero-posterior and a lateral radiographic projections paying attention to any alteration of Gilula arches. A CT scan can be useful because it allows to study more precisely the reciprocal articular relationship of carpal bones and possible presence of unrecognized fractures (19).

In one of his work, Marcuzzi (20), suggests the use of Vance classification (21) in order to evaluate correctly this type of injury (Tab. 1).

In accordance with the literature, since the trauma is complex, the risk of pseudarthrosis of the scaphoid, avascular necrosis of the capitate, wrist instability and osteoarthritis is high (22-26). Authors prefer open reduction and fixation of the fracture with the more correct hardware in relation to its pattern.

It is fundamental for the therapeutic success to restore the length of the capitatus in order to prevent the articular collapse (22), the reduction and the synthesis of any associated fractures and the realignment of the carpal joints lines in case of ligaments' injuries.

Usually dorsal approach is enough but sometimes, especially if there is a suffering of the median nerve, a double access, dorsal and volar, can be used (11). The synthesis can be performed with different devices (Kirschner wires, screws, metal staples or anchors useful for the reconstruction of any associated ligaments' injuries) (17).

When it is possible, Authors prefer the Herbert-type headless screws that allow the compression of the fracture both for the scaphoid and for the capitate with the insertion for the capitate from distally to proximally in order to protect the cartilage of midcarpal articular surfaces. In cases of multi-fragmentary fractures Kirschner wires are preferable. Furthermore, rehabilitation and physical therapies plays an important role for recovering from this lesion (27).

In any case the risk of complications is high despite good reduction and fixation, as confirmed by the clinical case reported in which an excellent reduction and stabilization of both fractures of the capitate and the scaphoid were obtained.

Despite this, an avascular necrosis of the capitate and a midcarpal osteoarthritis occurred. The reason why it occurred is not clear; however, it could be hy-

Table 1. Vance classification

Type one	The carpus is aligned, without any dislocation of carpal bones The head of the capitate (rotated 180°) is in contact with the concavity of the lunate
Type two	The carpus is dislocated dorsally with the head of the capitate (rotated 180°) respect to the lunate which remains in place
Type three	The carpus is dislocated dorsally The head of capitate (rotated 180°) is in contact with the suface of the lunate
Type four	Only the head of capitate (rotated 180°) is dislocated dorsally
Type five	The carpus is dislocated to volar side with the head of the capitate (rotated 180°) the lunate remains in place
Type six	There is volar dislocation only of the head of the capitate (rotated 180°)

pothesised that the cartilage of the midcarpal articular complex and the vascularisation of the proximal pole of the capitate were inevitably damaged and compromised by the high-energy trauma that caused the injury. Nevertheless, the reconstruction of carpal anatomy and stabilization of articular structures avoided joint instability and collapse, thus ensuring an excellent functional result with satisfaction of the patient who resumed his competitive activity just three months after surgery.

Conclusions

The scapho-capitate or Fenton syndrome is a rare carpal injury resulting from high-energy traumas where the fracture of the scaphoid is associated with the fracture of the proximal pole of the capitate which rotates of 90° or 180°. The treatment is surgical with different techniques and followed by intense and specific rehabilitation.

Nevertheless, it is a serious injury and the risk of complication is high despite good reduction and fixation.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Post-traumatic cystic lesion following radius fracture: a case report and literature review

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Summary. *Background:* Post-traumatic osseous cystic lesions represent a rare complication in children. Usually a post-fracture cyst is a lipid inclusion cyst, which is radiolucent and may be seen adjacent to a healing torus fracture. It is typically asymptomatic and appears just proximal to the fracture line within the area of subperiosteal new bone formation. *Case report:* We report a case of post-fracture cyst of the distal radius in an 8 year-old girl with spontaneous resolution. A fat-fluid level within the subperiosteal cystic lesion in MRI is a typical feature of post-traumatic cystic lesion in children. *Discussion and conclusion:* MRI or CT scan is sufficient to confirm the diagnosis of post-traumatic cystic lesions without the need for further management other than reassurance and advise that they may occasionally cause discomfort but resolve with time. (www.actabiomedica.it)

Key words: distal radius fracture, post-traumatic cyst, torus fracture

Background

Post-traumatic bone cystic lesions have been reported in the orthopaedic, paediatric and radiological literature (1) and represent a rare complication in children. They are radiolucent lesions that appear adjacent to a healing torus fractures (2). The cyst is usually a lipid inclusion developing from an intramedullary fat seepage through the damaged bone cortex and its entrapment within the subperiosteum (3). A typical feature of this kind of lesion is a fat fluid level within the subperiosteal cystic lesion in MRI. These lesions occur with a benign course and usually resolve spontaneously, but failure to recognize this condition can lead to an expensive diagnostic evaluation and create unnecessary apprehension (4). We report the case of an 8 years-old girl in whom such a lesion developed after a torus fracture of the distal radius.

Case Report

An eight-years-old girl presented with a painful right wrist after falling onto her outstretched right arm. The anteroposterior (AP) and lateral (L) X-ray of the right forearm revealed a greenstick fracture of distal radius with minimal dorsal angulation (Fig. 1 A, B). The forearm was immobilized in a below-elbow cast. X-ray examination at one week showed no change in the alignment and the cast was removed at three weeks. The final X-ray showed the complete healing of the fracture (Fig.2 A, B). Patient reported a new trauma on the same arm four months later and new X-rays were taken. While the final radiographs revealed healing process of the fracture, subsequent X-rays four months later showed a well-circumscribed radiolucent lesion without surrounding adjacent sclerosis to the site of the previous fracture (Fig. 3 A, B). The child was comfortable and afebrile with no signs of local inflammation at the cystic site. Whole blood cell count, C-reactive protein (CPR) levels (<1mg/L) and erythrocytes sedimentation rate (VES) were normal. Differential diagnosis needs to be done, included a pre-existing lesion (which was ruled out by the re-examination of the initial X-rays), infection as Brodie abscess formation or a true post-fracture cystic lesion. MRI of the right wrist showed a heterogeneous subpe-

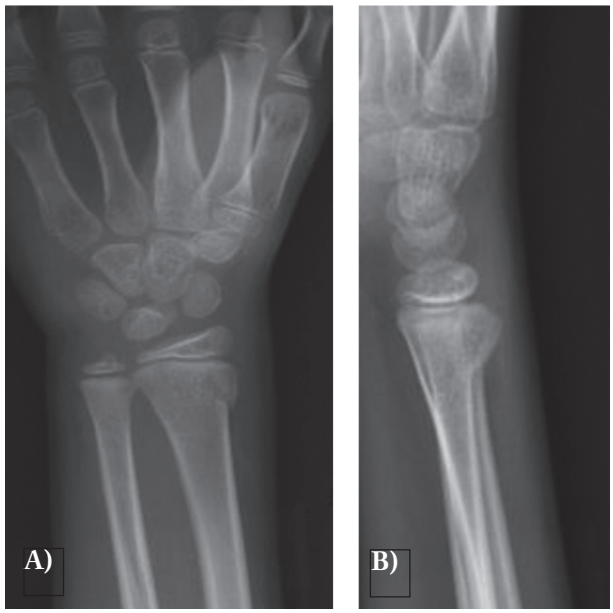

Figure 1. A, B. Torus distal radius fracture in 8-years old (AP and LL)

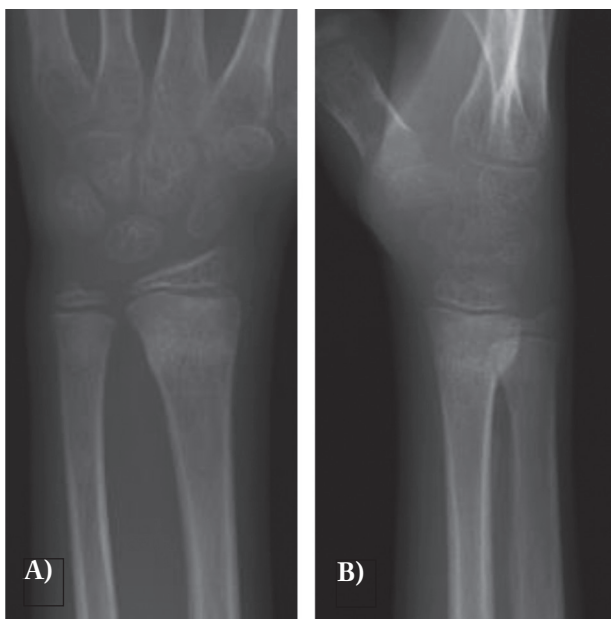

Figure 2. A, B. Final X-ray three weeks from trauma (bone healing)

riosteal cystic structure at the dorsal aspect of the right distal radius, measuring 10 mm (Anteroposterior) x 12 mm (Transverse) x 10 mm (Craniocaudal). It contained an upper layer of T1W hyperintensity which was suppressed on fat sat sequence consistent with fat content (Fig. 4 A, B). The lower layer was T1W

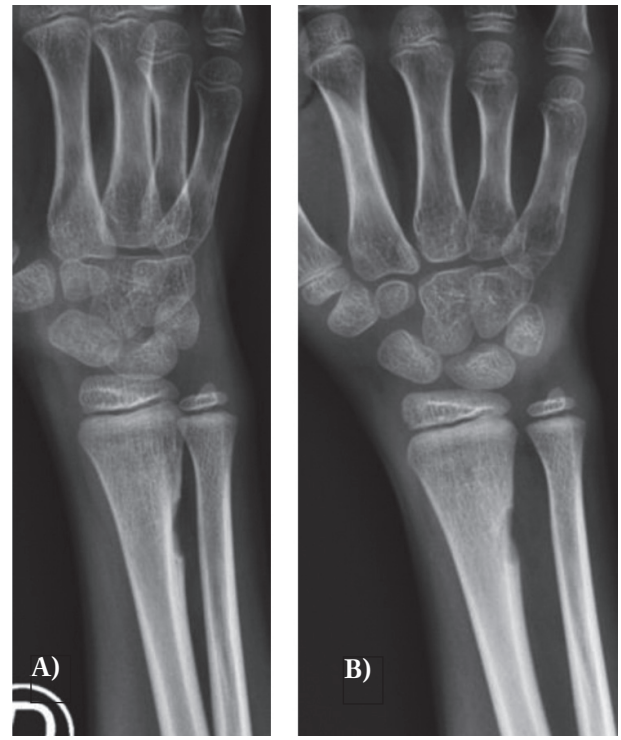

Figure 3. A, B. X-ray performed four months later from a new trauma

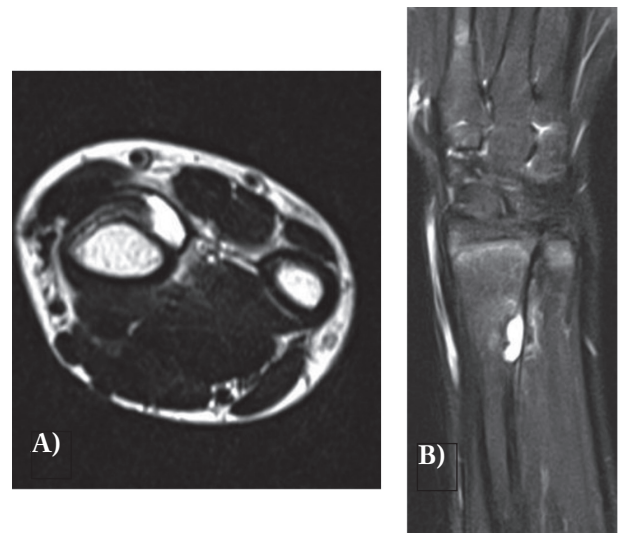

Figure 4. A, B. MRI of the cystic lesion

hypointense and T2W hyperintense and likely represented a chronic subperiosteal haematoma. The MRI features confirmed a fat-fluid level within the subperiosteal cystic lesion in MRI typical of post-traumatic

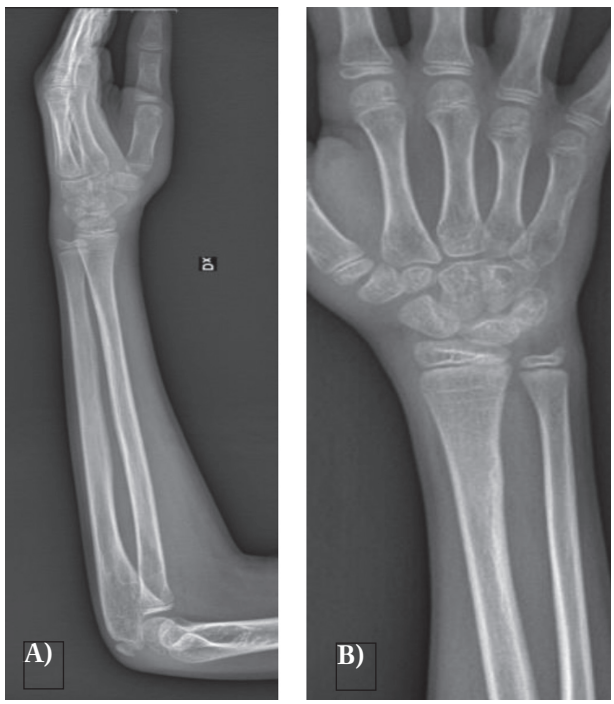

Figure 5. A, B. X-ray 1 year from the cyst diagnosis

osseous cystic lesion in children. Different from other literature cases, we performed a biopsy to obtain a histological confirmation of the benign nature of the cyst. The histological report of "a fibrous tissue without neoplastic cells and microcalcifications" confirmed the imaging. Clinically the child remained asymptomatic and was allowed to return to her normal sports activities and monitoring her as outpatient at six months. Radiographs at six months and one year from trauma showed that the cyst like lesion had disappeared and distal radius fracture had completely remodelled. (Fig. 5 A, B)

Discussion

Despite greenstick or torus fractures are common injuries in children, development of a cystic lesion after these fractures is relatively uncommon. Distal radius fracture seems to be the commonest site of development of these lesions (4, 5). Just over 20 cases of transient post-fracture cyst have been described in the orthopaedic literature. The most common location of the cyst-like lesion was the distal aspect of the radius and only a few of them were located in the distal aspect of the tibia (6, 7). (Tab. 1) These post-fracture cysts are probably more common than the published reports, because most distal radius fractures in children are monitored on clinical signs alone and their exact incidence is unknown (8). They were asymptomatic in all previously reported cases, in fact these lesions can be usually seen on routine follow-up X-rays and even as an incidental finding for evaluation of new reinjury after trivial trauma. They usually appear more than one month after the fracture a characteristically are less than 10 mm in diameter, do not expand, appear rounded or slightly oval shaped and may be multiple (8). There is a debate about the aetiology of transient post-fracture cysts. Pfister-Goedeke et al suggested that they are resorption cysts within an excessive periosteal reaction, related to the subperiosteal haematoma that accompanies greenstick fractures (9). Phillips and Keats attribute post-traumatic cysts to the resorption of intraosseous haemorrhage (6). Malghem et al reported that CT scan of two cases showed a density consistent with a fatty content, supporting the theory of transcortical escape of intramedullary fat. According to this theory the transient cyst could be the result of leakage of intramedullary fat during the fracture event, without disruption of the periosteoum. The entrapped fat could subsequently become visible, while the subperiosteal haematoma becomes calcified. In our study, T1W images, saturation T2W images demonstrated the presence of fat within the rounded cyst-like lesion, which strongly supports the theory of lipid escape from yellow bone marrow into the subperiosteal haematoma (10). This theory of transcortical escape of intramedullary fat is supported by Davids et al, who showed fat within a post-fracture cortical cyst on MRI (4). The rarity of the lesion is explained by the fact that two conditions must be fulfilled in order for development of a post-fracture cyst. The first is that the fracture shouldn't tear the periosteum but only detach it from bone, an event that usually occurs in children. The second condition is that the cortical defect allows extrusion of the squeezed bone-marrow fat. The time lag of at least 3-4 weeks before the lesion's first appearance is explained by the fact the surrounding haematoma usually becomes calcified after the follow-up

Table 1. Review of cases of post-traumatic cyst lesions reported in literature

Author	Patient number	Age (Years)	Location
Caffey (1988)	1	9	Distal radius (1)
Pfister-Goedeke and Braune (1981)	9	2.5-15	Distal radius (9)
Malghem and Maldague (1987)	2	6-10	Distal radius (1) Distal tibia (1)
Phillips and Keats (1986)	2	10-11	Distal radius (1) Distal tibia (1)
Malghem et al. (1990)	2	6-8	Distal radius (2)
Moore et al. (1988)	1	9	Distal radius (1)
Davids et al. (1993)	1	7	Distal radius (1)
Ball et al. (2001)	2	2.5-5.5	Distal radius (2)
Garcia-Alvarez f et al. (1999)	1	10	Distal radius (1)
Wass AR (1996)	1	9	Distal radius (1)
Durr et al. (1997)	1	6	Distal radius (1)
Talawadekar et al. (2009)	1	7	Distal radius (1)
total	***24***	***5.5***	***Distal radius (22)*** ***Distal tibia (2)***

period at which point we tend to examine radiologically a minimally displaced, complete metaphyseal or torus fracture (2).

The differential diagnosis of cyst-like cortical defects in children included unicameral bone cyst, non-ossifying fibroma, an eosinophilic granuloma, osteomyelitis, cystic bone tumors and transient cyst-like cortical defects (5, 11). Osteomyelitis was excluded in our patient based on clinical absence of signs of inflammation and normal WBC count and PCR. The possibility of a cystic bone tumor was excluded by the supporting history of trauma, X-ray and MRI which showed its localization proximal to the site of the fracture, the lack of sclerotic margins of the lesion and spontaneous disappearance of the lesion.

Conclusion

Post-traumatic cystic lesions of the bone remain an under reported entity and the aetiology remains unclear. These cysts rarely can present clinically with pain and soft tissue swelling at the previous fracture site, up to six months after the fracture. In all the reported literature, including our own, the cyst disappeared spontaneously. In the prototypical setting of post-traumatic cyst in a paediatric patient, MRI or CT scan is sufficient to confirm the diagnosis without the need for further management other than reassurance and advise that they may occasionally cause discomfort but resolve with time.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Combined radius addition osteotomy and ulnar shortening to correct extra-articular distal radius fracture malunion with severe radial deviation and ulnar plus

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Summary. Malunion can occur in 11 to 28% of Distal Radius Fractures and can result in radius shortening and ulnar plus with wrist deviation, pain and disability. We aimed to report particular cases of extra-articular distal radius fracture malunion with severe radial deviation and ulnar plus treated by corrective osteotomy of distal radius with bone graft associated to ulnar procedure. One of these patients was firstly operated with ulna subtraction osteotomy synthesized with plate and in a second stage with distal radius corrective addition osteotomy with homologous bone graft, plate and external fixator. Two other cases were treated in a single-step by radius addition osteotomy and caput ulnae Darrach resection. These three patients were followed-up from 2 to 12 years, successfully observing the maintenance of anatomical correction and recovery of ROM and strength with good pain relief and return to daily activities. After Darrach procedure external-fixation wasn't needed and pronation-supination was better. Darrach procedure can solve ulna plus and improve ROM in pronation-supination with a quicker healing, avoiding the risk of ulnar non-union. Darrach's procedure associated to addition corrective osteotomy of distal radius can be a valid treatment for distal radius severe malunion, in patients with low-moderate functional demand. In conclusion, the surgeon should choose the right corrective treatment after the complete evaluation of the patient and his functional needs. (www.actabiomedica.it)

Key words: distal radius, malunion, osteotomy, Darrach, bone graft, ulna plus, ulnar shortening

Introduction

Distal Radius Fracture (DRF) represents one of the most frequent fractures, accounting for up to 18% of all fractures in elderly (1). Malunion occurs in approximately 23% to 28% of conservatively treated and 11% of surgically treated DRF (2). Malunion can be intra- or extra- articular. Extra-articular malunion is characterized by the alteration of the radiographic parameters as shown by Graham: in sagittal plane lesser volar tilt or dorsal angulation and in coronal plane lesser ulnar tilt or radial deviation of the radius, often complicated with a shortening of the radius with augmented radio-ulnar variance resulting in instability of the Distal Radio-Ulnar Joint (DRUJ) (3). Lesions of the Triangular Fibro-Cartilage Complex (TFCC) could be associated.

The decision whether to and how to correct malunion is primarily based on age and functional demand of the patient and secondly on the level of functional impairment and wrist pain (2, 4, 5).

* Authors contributed equally

The goals of surgical correction are to re-establish pre-existent anatomy of the wrist, abolish pain and re-gain functionality, since these last two aspects are those that most influence the Quality of Life of patients (6).

We aim to report about the clinical and radiographical results obtained in three cases treated by corrective osteotomy of distal radius with bone graft associated to ulnar procedure.

Cases report

We report about three cases of extra-articular DRF complicated by malunion with severe anatomic deformation, treated at our Hand operative Unit between 2006 and 2016.

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.

Case 1 (Figg. 1-6)

The first case concerned a 59-years-old pianist with a bad outcome of his right DRF conservatively treated elsewhere two years before. He presented a severe deformity with radial deviation, reduced Range of Motion (ROM) with flexion=10°, extension=15°, pronation=45°, supination=0°, reduced grip force (Jamar= 14.8 Kg) and pain at the ulna-carpal joint (VAS=7). The X-ray highlighted a vicious consolidation of the radius and a plus of the ulna.

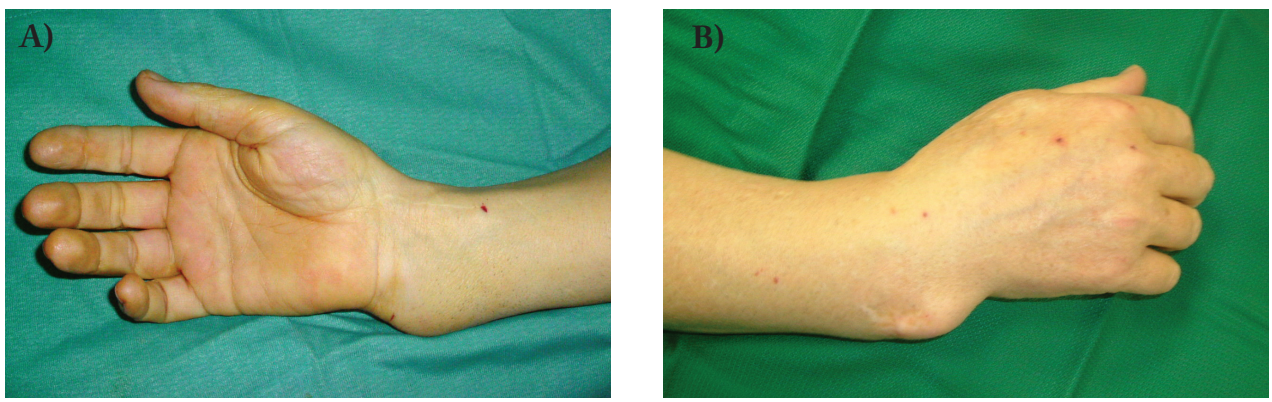


Figure 1 (Case 1). A) Clinical preop volar view; B) Clinical preop dorsal view

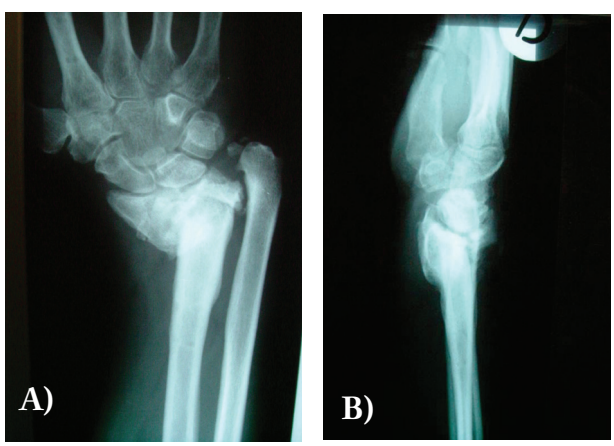


Figure 2 (Case 1). A) Preop AP view X-ray; B) Preop LL view X-ray

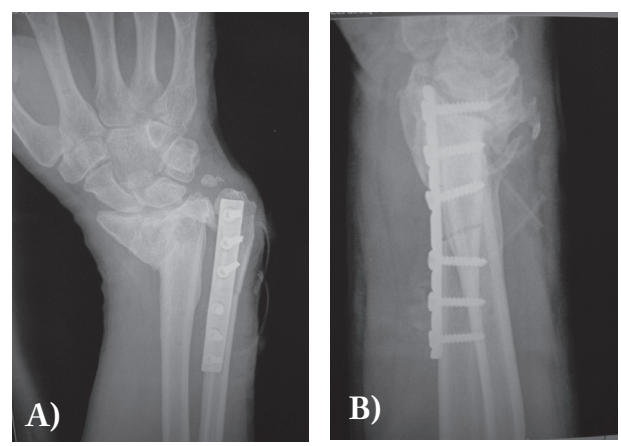


Figure 3 (Case 1). A) AP view X-ray post ulnar shortening; B) LL view X-ray post ulna shortening

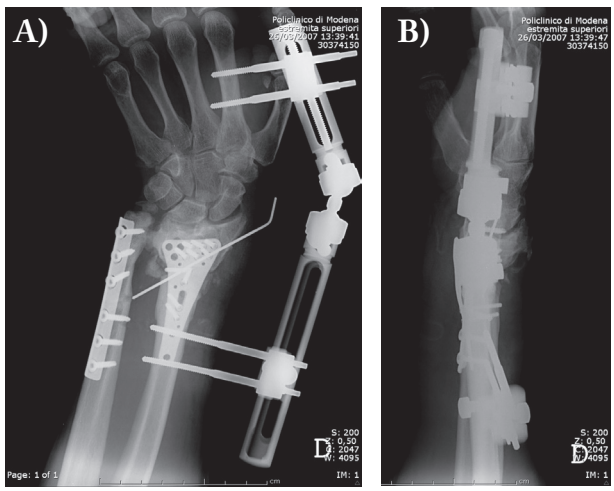


Figure 4 (Case 1). A) AP view X-ray post radius osteotomy with graft; B) LL view X-ray post radius osteotomy with graft

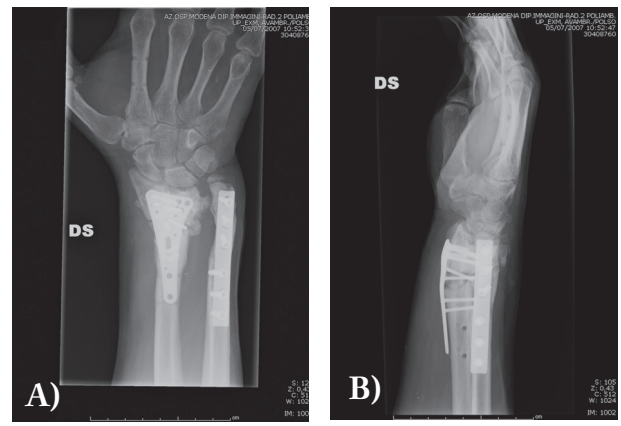
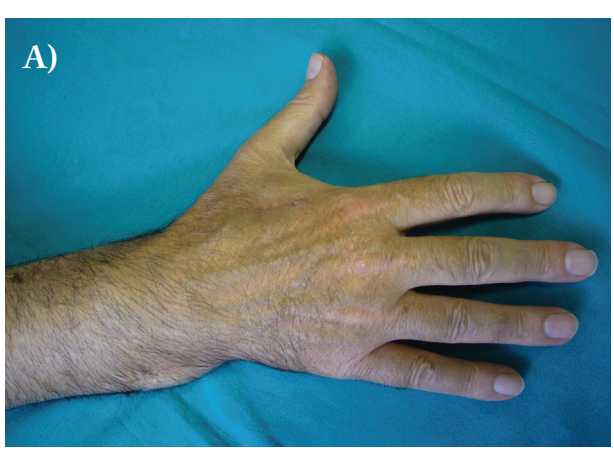


Figure 6 (Case 1): A) AP view X-ray 4 months post 2nd operation; B) LL view X-ray 4 months post 2nd operation

He firstly underwent subtractive osteotomy of the distal ulna and a new synthesis with plate and screws.

One year after, he underwent an open wedge corrective osteotomy of the radius with bone graft from iliac crest, a new osteo-synthesis with angular stability plate and temporary stabilization with Hofmann External Fixation System. He was clinically and radiologically followed-up at 1, 6 and 12 months and checked again after 12 years: the correction of deformities was maintained, with optimal aesthetic appearance of the hand. X-ray evidenced a good consolidation of the graft (Figg. 1-6).



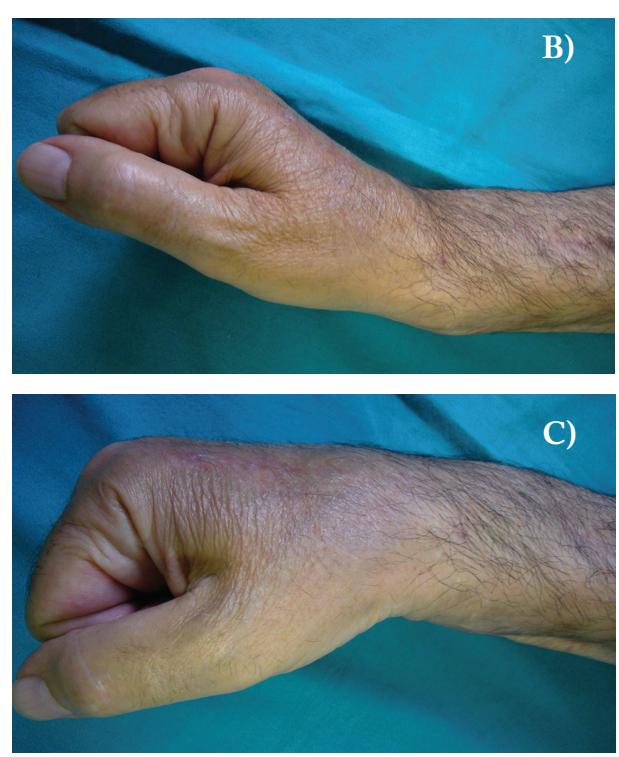


Figure 5 (Case 1): A) Clinical dorsal view 3 months post 2nd operation; B) Clinical lateral view in extension 3 months post 2nd operation; C) Clinical lateral view in flexion 3 months post 2nd operation

Table 1. Clinical outcomes of case 1

	PRE-correction	POST-correction
Flexion (°)	10	45
Extension (°)	15	60
Pronation (°)	45	85
Supination (°)	0	45
Grip Strength (Kg, Jamar)	14.8	18.9
Pain (VAS)	7	0

In this first case we observed (Tab. 1) improvement of wrist mobility (flexion=45°, extension=60°, pronation=85°, supination=45°), restoration of grip strength up to 18.9 Kg (Jamar) from 14.8 Kg and relief from pain (VAS=0, from 7).

Case 2 (Fig. 7)

The second case regarded a 75 years-old housewife who fractured her left distal radius and was conservatively treated elsewhere. She showed up at our attention presenting a severe deformity of the wrist, plus of the ulnar head, functional impairment (flexion 25°, extension 20°, pronation 60°, supination 40°) and exposition with infection of subcutaneous tissues, caused by decubitus of caput ulnae. X-ray showed malunion of the radius fracture with radial and dorsal angulation. She complained severe pain (VAS=6) and reduced grip strength (6.4 kg by Jamar).

The priority was given to the infection's treatment. Afterwards, the patient underwent a single stage corrective surgery including caput ulnae Darrach resection, distal radio-ulnar stabilization using one half of the Extensor Carpi Ulnaris (ECU) tendon, distal radius malunion reclamation with restoration of radius length by a spongy-cortical bone graft from iliac crest and a new osteosynthesis with plate. At 18 months of follow-up we observed a restoration of the ROM and pain relief maintained up to the last check after 3 years (Fig. 7).

This second patient (Tab. 2) achieved a good recovery of ROM with 40° of flexion, 65° extension, 80° pronation, 85° supination, improvement of grip strength up to 12.5 kg (Jamar) from 6.4 Kg and relief from pain (VAS=0, from 6).

Case 3 (Fig. 8-10)

The last case affected a 67 years old restaurateur who fractured his left distal radius and was treated elsewhere by percutaneous pinning. Because he complained pain (VAS=8) and residual functional impairment with flexion 20°, extension 15°, pronation 0°, supination 0° and grip strength (Jamar) 4.5 kg, he underwent further exams: a CT scan documented malunion of the radius fracture with lift of the proximal stump and ulnar plus variance. A Leukoscan Total Body Scintigraphy pointed out an iperactivity of the radiocompound in the site of the previous fracture and on the left carpal bones, suspicious for overlapping infection.

The extemporaneous histological examination excluded infection (less than 5 PMNs for field) and so this third patient was treated in the same way as the second one.

The patient was clinically and radiologically followed-up at 1, 6, 12 and 24 months post-op. (Figg. 8-10).

In this third case we observed (Tab. 3) a restoration of 60° in flexion, 50° in extension and 85° for both pronation and supination, improvement of grip strength up to 9.2 kg (Jamar) from 4.5 Kg, and pain relief (VAS=2, from 8).

In all the treated patients anatomy and function of the wrist have been restored with a mean gain of flexion of 30°, 42° for extension, 55° for pronation and 58° for supination; mean grip strength was improved of 5.0 kg and mean pain reduced of 6.3 VAS points.

Discussion

Malunion, or vicious consolidation, is a possible complication of DRF, mostly after conservative treatment of displaced unstable fractures (2). Clinically it can result in wrist deformity, rigidity with reduced ROM, pain and reduced force. Severe deformity of distal radius associated to ulnar plus is disabling and may need surgical correction. Restoring the normal alignment and articular congruity is important in order to obtain good functional results (7). Aim of the surgi-

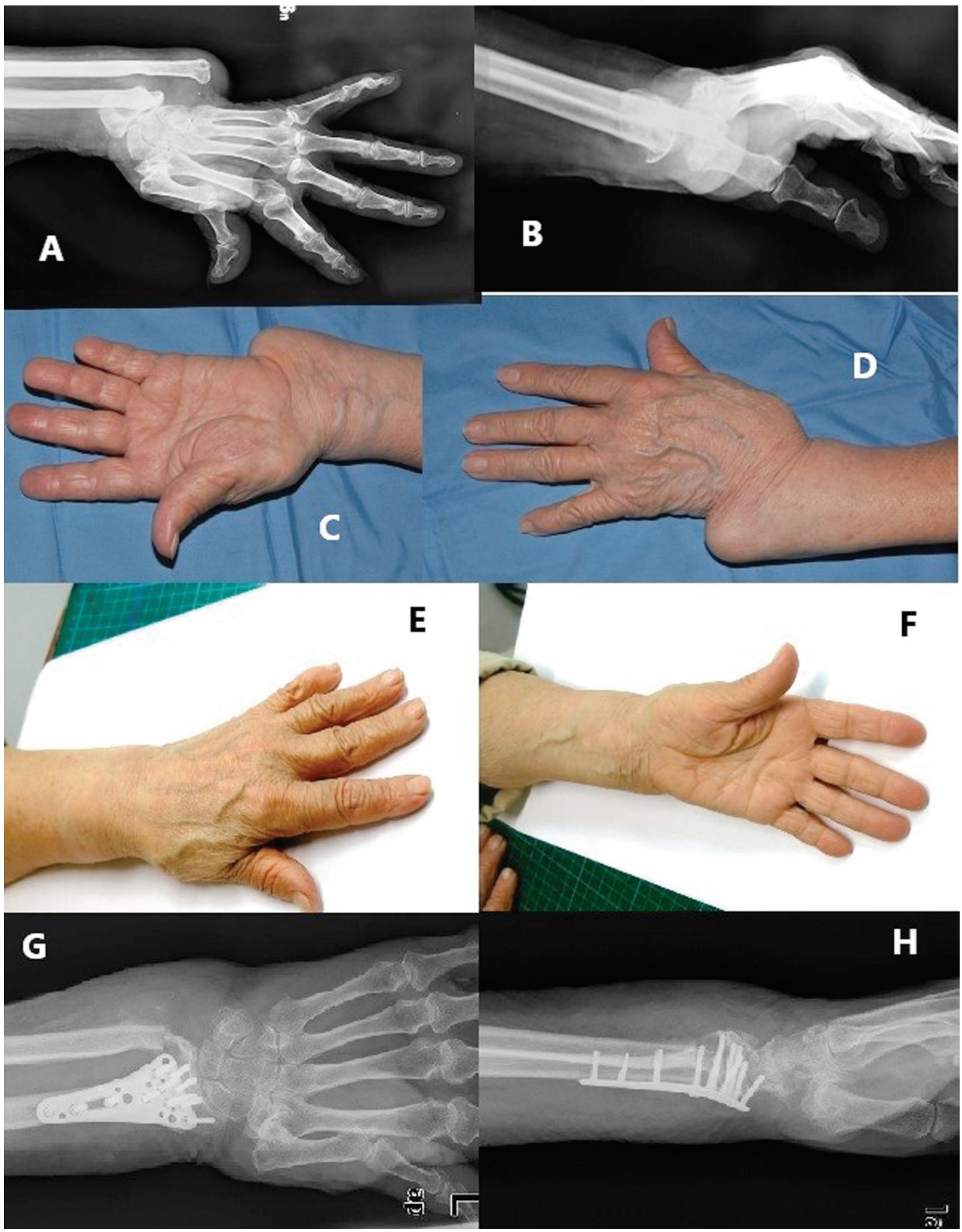


Figure 7 (Case 2): A,B,C,D) Severe wrist deformity with radial deviation and plus of the ulna; A) A/P X-ray; B) L/L X-ray; C) clinical palmar view; D) dorsal view. E,F,G,H) Result 6 months after corrective surgery with Darrach procedure and distal radius addition corrective osteotomy; E) clinical dorsal view; F) palmar view; G) A/P X-ray with plate; H) L/L X-ray with plate

Table 2. Clinical outcomes of case 2

	PRE-correction	POST-correction
Flexion (°)	25	40
Extension (°)	20	65
Pronation (°)	60	80
Supination (°)	40	85
Grip Strength (Kg, Jamar)	6.4	12.5
Pain (VAS)	6	0

cal treatment is to correct deformity in order to restore function with an adequate ROM and strength and relief of pain to ameliorate Quality of Life (8). Ultimately reducing discomfort improves patient satisfaction (9).

There are different surgical options: the most reported is the association of radial corrective osteotomy with ulnar shortening osteotomy (4,10,11). The latter offers the advantage to re-establish the articular congruity respecting the DRUJ, but on the other hand needs a new synthesis which requires a longer time of healing and could result in non-union. This risk is not contemplated for Darrach's procedure, which avoids temporary stabilization; nevertheless, this procedure is not free of complications: infact it can cause DRUJ instability (12).

Despite treated in different ways, all the three patients reached satisfactory results. In particoular we treated the first patient in two times and shortening ulna in order to respect the DRUJ, but, up to date, due

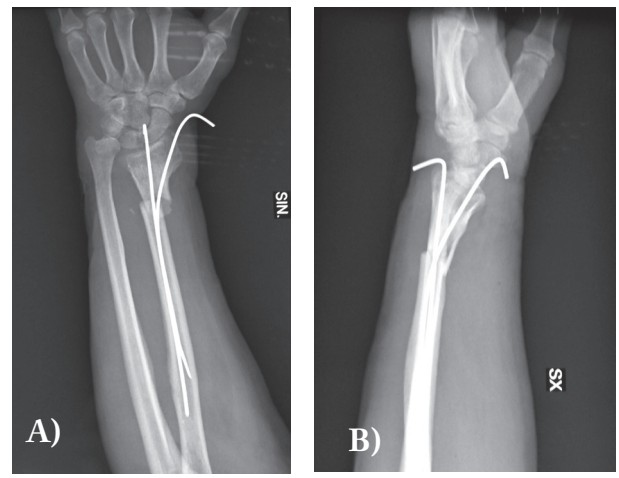


Figure 9 (Case 3). A) Preop AP X-ray; B) 3b Preop. LL X-ray

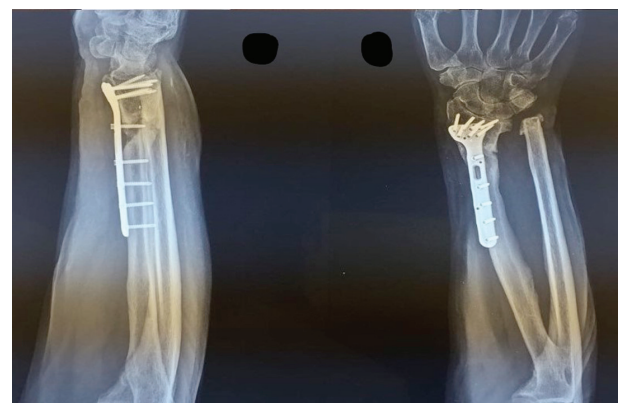
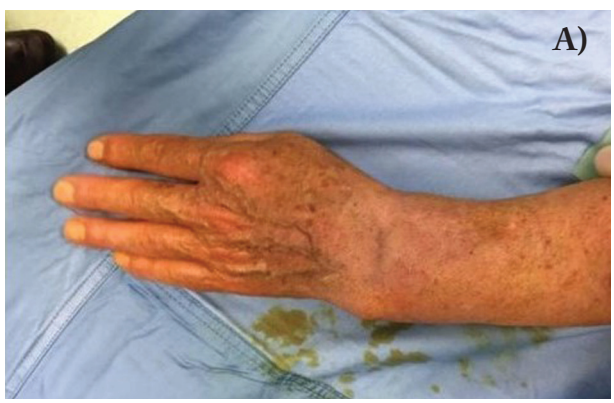


Figure 10 (Case 3). 3 months post-op X-ray.



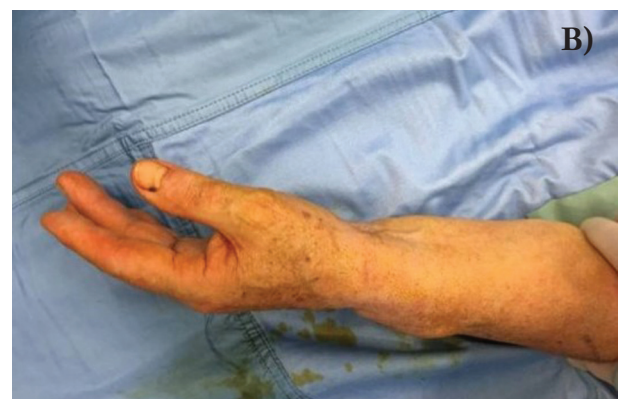


Figure 8 (Case 3): A) Preop. clinical dorsal view; B) Preop. clinical lateral view

Table 3. Clinical outcomes of case 3

	PRE-correction	**POST-correction**
Flexion (°)	20	60
Extension (°)	15	50
Pronation (°)	0	85
Supination (°)	0	85
Grip Strength (Kg, Jamar)	4.5	9.2
Pain (VAS)	8	2

to our good outcomes, we would treat him in the same way as the other two patients, with radius corrective osteotomy, homologous bone graft, new synthesis with plate and Darrach ulnar procedure, with the advantage of a good and quick recovery of pronation-supination in a single surgical time.

We can say that Darrach's procedure, if opportunely stabilized, associated to addition corrective osteotomy of distal radius, can be a valid treatment for distal radius malunion with severe deformity, in selected patients with low to moderate functional demand. Ulnar shortening osteotomy remains the first treatment option in younger and highly demanding people, because more conservative towards the DRUJ. In conclusion, the surgeon should choose the right corrective treatment after the complete evaluation of the patient and his functional needs.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Groin pain caused by iliopsoas synovial cyst treated with endoscopic approach. A case report

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Summary. The diagnosis of iliopsoas synovial cyst is a rare finding. The normal approach to treat this condition has been conservative therapies or open surgery, with its associated complications and morbidity. The arthroscopic – endoscopic surgery is less invasive and with an increase in complications and days of hospitalization. We report the case of a 70-year old woman with clinical and imaging signs of a fluid-filled cyst near iliopsoas distal tendon. After fluid aspiration, the patient reported symptom-free interval of several weeks, but then groin pain and swelling feeling return, increased with hip movements. The cyst was removed through arthroscopy approach and the iliopsoas tendon was released. The removal of iliopsoas synovial cyst is necessary to avoid complications such as pain and functional limits. Arthroscopy has the advantage of less soft-tissue damage and quicker recovery. The treatment of associated tendon pathology can be done. Hip arthroscopy can be a safe and effective technique for the removal of iliopsoas synovial cyst. (www.actabiomedica.it)

Key words: ilio-psoas, groin pain, synovial, cyst, endoscopic surgery

Introduction

Chronic pain with or without a palpable inguinal swelling near groin and hip region has many potential causes and is a frequent problem in the population with a lot of underlying pathologies (1). The most common regard osteoarthritis, joint contracture, muscle and tendons strains, inguinal or femoral hernia, bursitis, stress fracture, or femoro-acetabular impingement (2).

Even previous arthroplasty can lead to an unexplained groin pain (3). We have previously described two causes of pain after total hip replacement, due to anatomical problems such as iliopsoas impingement or heterotopic ossification (4, 5).

Irritation of the iliopsoas tendon due to the presence of an idiopathic cyst is a rare and underestimated cause of dull groin pain and functional disability of the hip with a real rare incidence. Pain specific to iliopsoas tendonitis includes activities such as hyperextension of the hip, forced flexion, and activities of daily living like ascending stairs (6).

A synovial cyst is usually an enlarged iliopsoas bursa in communication with the capsule of the hip joint. Increased secretion in arthritic joints may cause distension of this bursa. Generally, inguinal mass could be a late complication of hip arthroplasty and these symptomatic cysts usually need removing by an anterior approach (7).

Imaging plays an important role in the diagnosis of these entities, using conventional radiographs, ultrasound (US) and magnetic resonance (MRI) (8). MRI and US are valuable in diagnosing pathology in patients with groin pain (9).

This article presents a case of a 70-year old woman affected by Horton arthritis with clinical, ultrasound and magnetic resonance imaging signs of a fluid-filled sac cavity near iliopsoas distal tendon. Three ultrasound-guided cystic fluid samples were

performed. The analysis reported synovial fluid. After each aspiration, the patient reported symptom-free interval of several weeks, followed by groin pain and swelling feeling that increased with hip movements. Finally, magnetic resonance imaging of the hip showed a surface fluid-filled cyst in anatomical proximity to the iliopsoas distal tendon and pectineus muscle. The cyst was removed through arthroscopy approach and the iliopsoas tendon was released.

Case report

A 70-year old woman presented to our attention, with inguinal swelling and groin pain since about two years. She was affected by Horton arthritis. Ultrasound analysis reported a fluid buildup of 4 x 5 cm large. A magnetic resonance survey was done. It showed the same fluid collection located between iliopsoas and pectineus muscles, displacing the neurovascular bundle but with independent anatomical relationships.

A rheumatological evaluation was done. After this investigation an ultrasound-guided cystic fluid aspiration was performed with a 60cc evacuation of synovial fluid, yellow colored, normal viscosity. The fluid was analyzed in our laboratories. Chemical-physical and microbiological exam showed synovial fluid without evidence of leukocytes and microbial growth.

Other 2 aspiration were performed. The symptoms used to relief after cyst aspiration but then increase again showing the recur of the mass.

One year after the first medical evaluation, a clinical orthopedic examination revealed rotational groin pain and painful movements after forced flexion over 100°. A palpable swelling laterally of the neurovascular bundle of about 3 cm could be observed. Palpation consistence was tight, sliding on the superficial planes, and its limits were rather net. She presented slight pain on palpation, and it increases with hip mobilization. The skin presented normal color and temperature.

A RX and a new RMN were done looking for any anatomical changes of the cyst. The imaging showed no change compared to previous surveys (figure 1), confirming the presence of a large cyst near the iliopsoas tendon, in a generalized osteoarthritis condition (figure 2). In consideration of the no improvement in

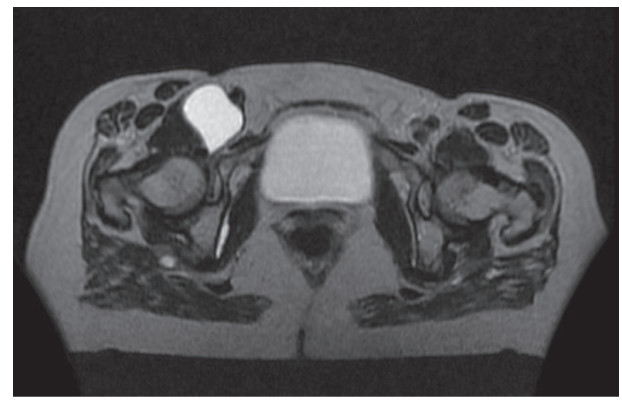

Figure 1. RMN shows cyst near iliopsoas tendon

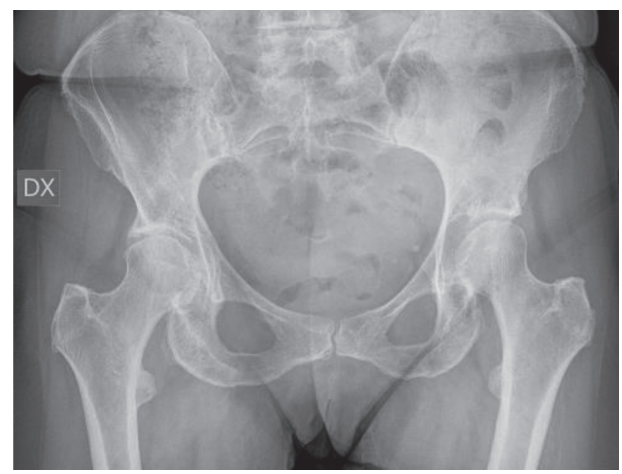

Figure 2. Osteoarthritis hip condition

symptoms, the clinical and imaging status, a surgical indication was given. It had been decided for an endoscopic removal, using the instruments of hip arthroscopy.

The patient underwent resection of the cyst via an anterior and antero-lateral "arthroscopic" approach (figure 3) doing and extracapsular arthroscopic approach (10). Surgical approach confirmed that the cyst originated from the iliopsoas tendon muscle. A relationship to the hip joint was not present. The cyst was opened with limpid synovial liquid leaking (figure 4). The lateral wall and part of the medial part were removed. Iliopsoas tendon was partially released.

Postoperative non active hip flexion activities were allowed. There were no complications in wound healing. The patient was pain free a few weeks postoperatively. At 12-month follow-up, the patient was

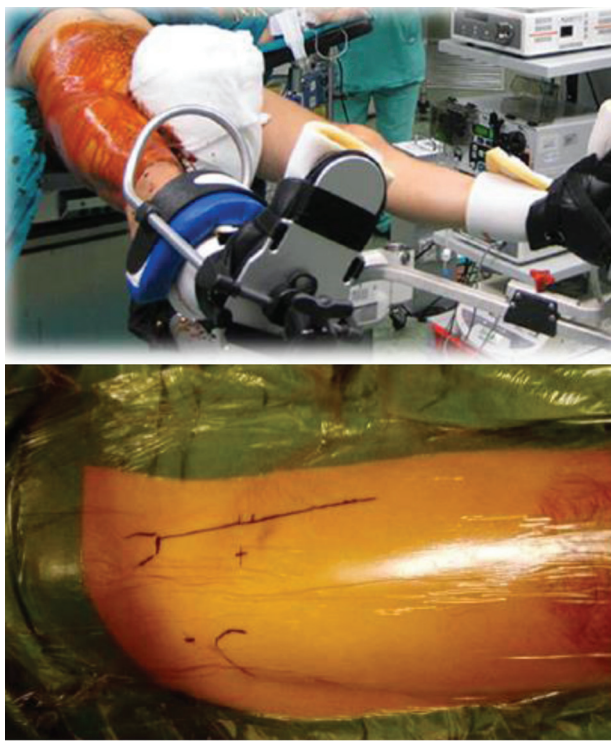

Figure 3. Arthroscopic approach

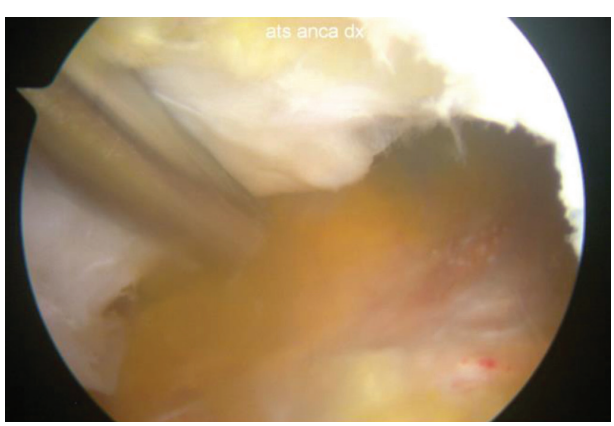

Figure 4. Iliopsoas cyst with synovial liquid inside

symptom free. Activities of daily living were possible without any problems.

Discussion

The primary groin pain without an apparent cause, is part of a wide differential diagnosis. Causes can be different, and among these there may be the presence of a cystic lesion near iliopsoas tendon. Rarely this type of disease can be treated arthroscopically. From this point of view the cyst can be para labial, and it can be caused by an impingement iliopsoas (11). An even more rare occurrence in the literature, it can be derived from iliopsoas. The final effect is an inflammation of the iliopsoas tendon with clinical manifestations such as pain on palpation and active and passive mobilization of hip.

The diagnosis of iliopsoas tendonitis may be difficult. Different imaging modalities like radiograph, ultrasound and CT may be helpful to exclude bursitis, tendinitis or other causes.

Falvey et al. have studied how MRI has an important value in the evaluation and diagnosis of inguinal pain (12). Magnetic resonance imaging is the most sensitive study to determine soft tissue pathologies (13).

The therapeutic approach must be multidisciplinary. The surgical one should be the last option to be considered.

In our patient, groin pain was due to a cystic formation near iliopsoas tendon. Clinical and imaging investigation (ultrasound, CT) ruled out any other causes. The first therapeutic choice was for a conservative approach; after a year of no improving of the symptomatology, it was decided for a surgical treatment.

Iliopsoas tendonitis should be considered in the differential diagnosis of all patients with the presented symptoms. Other causes should be ruled out. Temporary pain relief can be achieved by local aspiration. For final therapy, a surgical treatment, consisting of the removal of possible cysts with the release of iliopsoas tendon is recommended.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Rectus femoris myotendinous lesion treated with PRP: a case report

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Summary. *Background and aim of work:* Musculoskeletal injuries are the most common cause of severe, chronic pain and physical disability for the majority of all sport-related injuries. Platelet-rich plasma is being used more frequently to promote healing of muscle injuries. We report a case of 39 years old non professional soccer player who came to our attention for a quadriceps muscle pain onset after kicking the ball during a match. *Methods:* Clinical and instrumental evaluation revealed a myotendinous junction rupture of the rectus femoris with retraction of 1.5 cm from the anterior inferior iliac spine. We decided to treat the patient with PRP ultrasound guided injections and a specific rehabilitation protocol. *Results:* Clinical evaluation 45 days following the end of the treatment showed the resolution of the pain and the full recovery of strength and range of motion. Muscle healing was documented by magnetic resonance imaging. *Conclusions:* Even if the role of PRP in muscle injury is not still clear, the result observed confirms that it could be used in the treatment of muscle lesions. (www.actabiomedica.it)

Key words: rectus femoris, rupture, injury, PRP, muscle

Introduction

Musculoskeletal injuries represent a challenging problem for traumatology and sports medicine, as they are the most common cause of severe long-term pain and physical disability for the majority of athletes (1).

The quadriceps and hamstring muscle groups are more commonly affected by strains and avulsions.

The most common type of quadriceps injury is an intramuscular strain at the myotendinous junction (2, 3).

Proximal lesions of the rectus femoris in adult athletes are not commonly reported. Their optimal treatment is controversial; it is usually conservative but in some cases, especially in high level athletes with myotendinous retraction ≥ 1.5 cm or in adolescent with avulsion and displacement ≥ 2cm, surgery may be indicated (4-7).

In those lesions treated conservatively healing occurs slowly and it depends on their gravity (approximately 4-12 weeks); athletes are discouraged to resume their sport activity until walking without pain is possible. During this period, it has been demonstrated that the long recovery period may be also due to the structural alterations of the myotendinous junction induced by too long immobilization (8-10). For this reason, it is commonly accepted that a quick mobilization associated with specific rehabilitation and physical therapies facilitates an adequate structural resolution of the lesion (11). Also platelet rich plasma (PRP) injections may favour this process.

PRP is a biological blood product obtained from the patient, which has anti-inflammatory and pro-regenerative functions (12-14).

It has been demonstrated that PRP is able to in-

duce proliferation of muscle cells, differentiation of satellite cells, and facilitate angiogenesis (15, 16). In a clinical context, it has been reported that full recovery of functional capabilities could be restored in a smaller time when compared to other treatments (17-19).

However, results described by different research groups are conflicting and did not provide full support to the use of PRP for the treatment of muscle injuries.

For these reasons additional investigations should be important to better clarify PRP clinical applications (20, 21).

Case report

A 39-year-old non professional soccer player arrived in our Emergency Department complaining of pain in his anterior thigh near the insertion of the rectus femoris on the anterior inferior iliac spine (AIIS), which happened during a football match; he referred a feeling of snapping in the same zone.

The patient walked with the help of two crutches because he was unable to weight bear freely due to pain.

An evident hematoma in the region mentioned above was noticeable.

On physical examination there was pain due to manual pressure, a deficit of strength in hip flexion against manual resistance and a gap in the AIIS region which was clinically palpable. For this reason we suspected a lesion/avulsion of proximal rectus femoris.

An ultrasound study confirmed our suspicion and showed the presence of hematoma at the myo-tendinous junction with fascial blood layers and tendon rupture of the proximal rectus femoris (Figure 1).

Furthermore, magnetic resonance imaging (MRI) performed 7 days later confirmed the diagnosis and showed a lesion of the myotendinous junction characterized by partial lesion of the direct head and total lesion of the indirect head of the tendon with retraction of 1.5 cm associated to edema and hematoma (Figure 2).

In that moment the patient got better. He did not use crutches, he had less pain during his daily life and he had less pain both in manual pressure and in tests against manual resistance.

In the face of this clinical improvement we decided to not consider the surgical option and to treat the patient with ultrasound guided PRP injections and a specific rehabilitation program, which was initially based on isometric exercises and, later, on eccentric work exercises and it was always accompanied by tecartherapy.

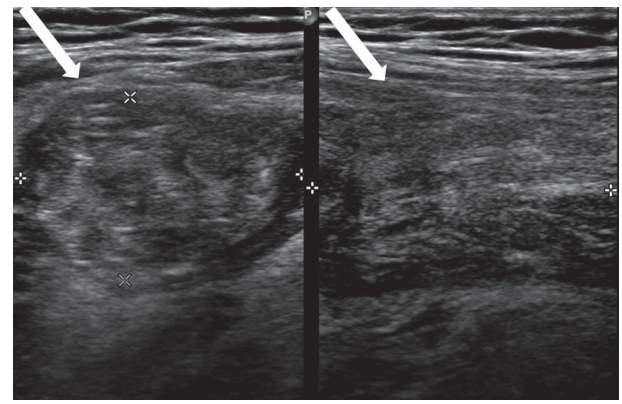

Figure 1. Ultrasonography performed at the Emergency Department with muscle rupture (arrows)

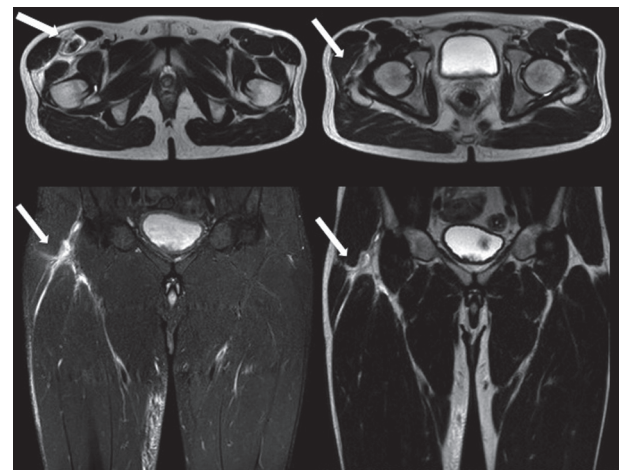

Figure 2. MRI performed 6 days after injury with the signs of myotendinous lesion and retraction (arrows); coronal and axial views

An autologous blood sample of the patient was taken by the Transfusion Center of the University Hospital of Parma. From this sample, 3 stocks of PRP were obtained. The injections were done 10, 20 and 30 days after injury (5 ml of PRP and 1 of thrombin) under ultrasound guidance.

Following the first infiltration the patient reported a progressive improvement in symptoms and a progressive decrease in pain.

Fifteen days after the end of the infiltrative cycle another evaluation showed the absence of pain and

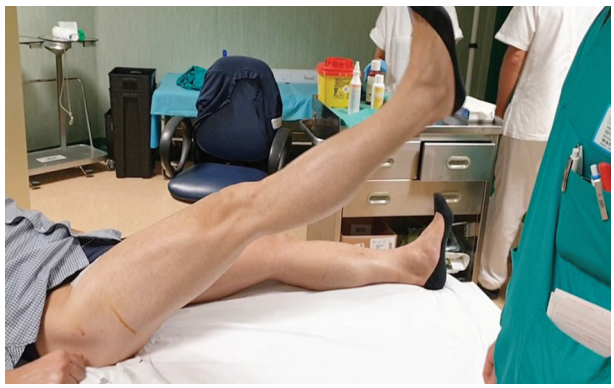

Figure 3. Clinical evalutation 15 days after the end of the infiltrative cycle

the patient referred to walk freely without limitations in his daily life, even if a deficit of strength against manual resistance was present (Figure 3).

We therefore planned a new MRI and clinical evaluation 45 days after the end of the infiltrative cycle.

In the meantime, the patient continued the rehabilitation program, including concentric exercises against elastic resistance.

At the final clinical check the patient did no longer complain of pain. There was no more gap in the AIIS region, the range of motion was 0°-130° bilaterally and there was no deficit of strength against manual resistance. The MRI confirmed the advanced stage of healing as no longer hematoma was appreciable and edema had almost completely disappeared (Figure 4 and 5).

The patient returned to his sports activity without any problems 90 days after injury.

Discussion

Musculoskeletal injuries represent a challenging problem for traumatology and sports medicine; they are the most common cause of severe, chronic pain and physical disability for the majority of all sport-related injuries (1, 22, 23).

In addiction to the clinical examination, imaging plays a key role in the diagnosis of these lesions; in fact clinical assessment may not be sufficient for distinguishing contusions from tears or for estimating the size of the lesion and the entity of the muscular retraction (24).

Ultrasound offers both static and dynamic views of the quadriceps; given the low cost and expanding availability of the technology it has to be considered an excellent first step in evaluation (25).

Nevertheless, MRI is the gold standard to define the gravity of these lesions and it allows a more global multidimensional assessment. Hematoma may be observed in case of complete tears and may have various

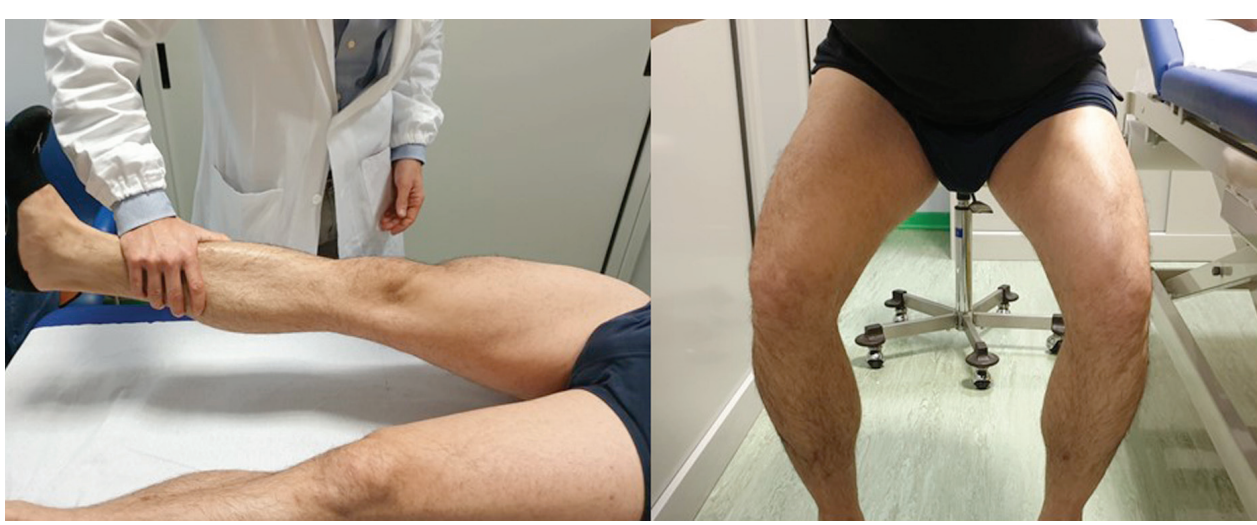

Figure 4. Clinical evaluation 45 days following the infiltrative cycle

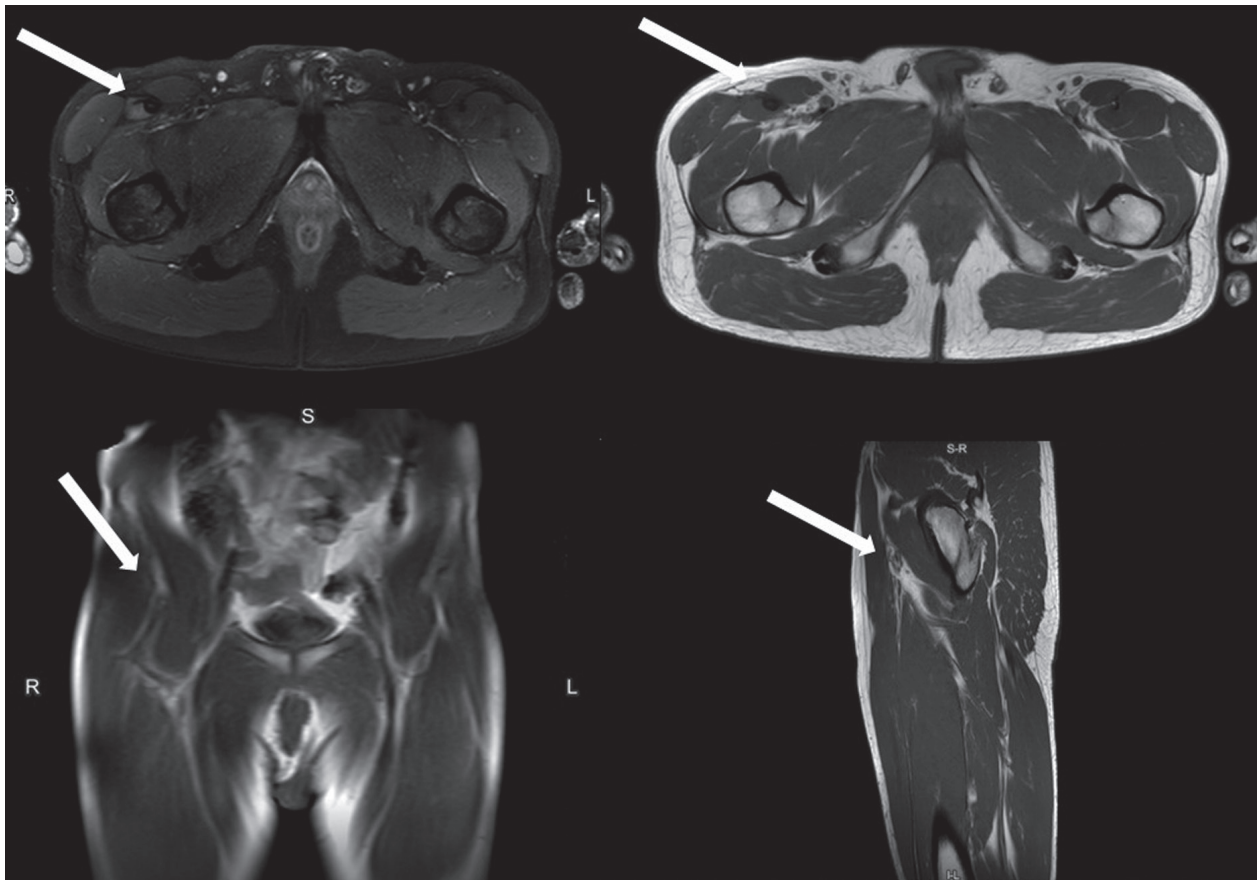

Figure 5. MRI 45 days following the infiltrative cycle with advanced signs of healing (arrows)

signal intensities according to the time elapsed since the injury. These imaging tools are also important to follow the healing process and to detect complication occurrence thus reducing sports inactivity duration (26).

Quadriceps and hamstring muscle groups are more commonly affected by strain and avulsion injuries.

The most common type of quadriceps injury is an intramuscular strain at the myotendinous junction (3, 27).

From a histochemical point of view, in fact, the most evident effect is a dramatic reduction of glycosaminoglycans at the level of the muscle-tendon interface; moreover, there is an increase in type 3 collagen compared to type 1 collagen.

Type 3 collagen appears weaker from a biomechanical point of view than type 1, which is the basic collagen of myotendinous junction and tendon. Wrong training and inactivity accentuate this.

There is, in fact, growing evidence that these conditions play a key role in these structural modifications thus leading to a reduction in strength and elasticity at the level in the tendon and myotendinous junction (26).

Proximal lesions of the rectus femoris in adult athletes are not commonly reported, and their optimal treatment may vary (4). It is usually conservative and surgery has limited indications (high level athletes with myotendinous retraction ≥ 1.5 cm or in adolescent with avulsion and displacement ≥ 2cm) (4-7).

Healing time depends on the grade of rupture and athletes are discouraged to resume their sport activity until walking without pain is possible (approximately 4-12 weeks). During this period, it has been demon-

strated that the long recovery period may be also due to the structural alterations of the myotendinous junction induced by the excessive immobilization after the injury (8, 10).

For this reason, it is commonly accepted that a quick mobilization, followed by a specific rehabilitation program and physical therapies, may facilitate an adequate structural resolution of the injury. PRP injections can further favour this process (11).

The therapeutic program initially starts with isometric exercises. After few days, and after the acute phase and the articular excursion is recovered, eccentric and concentric isotonic exercises were introduced as well as progressive stretching. Exercises must always be performed below the pain threshold for the duration of rehabilitation and can be associated to physical therapies.

PRP is a biological blood product obtained from the patient, which has anti-inflammatory and pro-regenerative functions (12) and is being used more frequently to promote healing of muscle injuries (28-30).

There is abundant evidence suggesting that growth factors may play a key role in the healing process, especially in the early stages of inflammation (13); in fact it has been demonstrated that PRP is able to induce proliferation of muscle cells, differentiation of satellite cells, and facilitate angiogenesis (15, 16).

In a clinical context, it has been reported that full recovery of functional capabilities was restored in a smaller time when compared to other treatments (11).

Despite the reported clinical successes with the use of growth factors there is still a lack of knowledge on the biological mechanism underlying the activity of platelet-rich plasma during the process of muscle healing (13); results of studies performed by different research groups are conflicting and did not provide full support to the use of PRP for the treatment of muscle injuries. For these reasons additional investigations would be important to better clarify PRP clinical applications in these kinds of injuries (20,21).

The satisfactory outcome of this case report confirms that PRP injections associated to specific rehabilitation may play a key role in the treatment of muscular lesions. Authors believe that PRP injections has to be performed with the assistance of ultrasound and in the early stage of inflammation.

Conclusions

Proximal lesions of the rectus femoris in adult athletes are not commonly reported and their therapeutic management remains controversial. MRI is the diagnostic and prognostic gold standard exam. Although the surgical option is a choice in selected cases, conservative approach is the standardized treatment in most patients. In this perspective, PRP associated with rehabilitation and physical therapy may play a key role both in the healing of the lesion and in the early recovery of physical activity.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Late bleeding during anterior approach to the hip: case report

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Summary. Vascular injuries represent an uncommon complication of total hip arthroplasty, with an incidence of 0.1-0.3% as reported in the literature. The aim of the study is the description of a case of late bleeding in a female patient undergoing surgery for total hip arthroplasty in right osteoarthritis through direct anterior approach. The treatment carried out was a selective embolization of the main ascending branch of the lateral circumflex artery. This was performed by placing two spirals following an angiography, which was revealing an active spreading of contrast at the right femoral circumflex ascending artery. The effectiveness of endovascular techniques for the treatment of early and late bleeding after surgery is pointed out. (www.actabiomedica.it)

Key words: direct anterior hip approach, artery embolization, late bleeding

Introduction

Vascular injuries represent an uncommon complication of total hip arthroplasty, with an incidence reported in the literature of 0.1-0.3%; the frequency is higher during revision surgery (1). Acetabular penetration, reaming and screw fixation, extraction of the acetabular component, femoral cerclage wires and inappropriate placement of anterior acetabular retractors (2, 3) are, as reported, common causes of vascular damage. Spontaneous rupture of the femoral artery through atherosclerotic plaques has also been described (4). Distal extension of the direct anterior approach, may increase the risk of vascular injuries (5). The aim of this study, describing a case of late bleeding in a female patient undergoing surgery for total hip arthroplasty via anterior approach, is to highlight the effectiveness of endovascular techniques for the treatment of early and late bleeding after surgery.

Case report

In June 2016, a 76-year-old female patient with a history of symptomatic osteoarthritis of the right hip received a total hip arthroplasty (MicroPort Orthopaedics®, Arlington, TN, USA) by anterior approach. There was nothing significant in her medical history, blood and instrumental exams performed during the preparation to surgery were regular. During the perioperative surgery period the patient was undergoing to anti-DVT, antibiotic and anti-ossification prophylaxis according to the hospital protocol. During the surgery, the branch of the lateral circumflex was tied. Post-operative course was regular and after five days from surgery the patient was transferred to Rehabilitation department. On the 19th postoperative day the patient was subject to sudden onset of painful swelling on the right thigh. After Orthopaedic evaluation, a Color-Doppler-Ultrasound confirmed the presence of a hematoma partially arranged at the level of the swelling (13x5 cm). This hematoma was not apparently supplied. On the 22nd postoperative day, due to a persistence of low haemoglobin level, the patient has been subjected to an angio-CT which revealed an active arterial bleeding (Fig 1, Fig. 2).

An angiogram with retrograde left femoral access showed an active spreading of contrast solution at the right ascending femoral circumflex artery (Fig. 3,

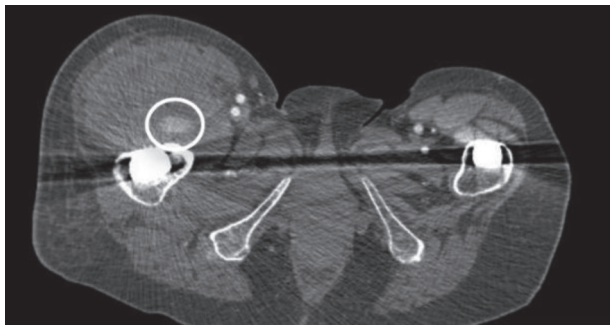

Figure 1. Active arterial bleeding on angio-CT scan

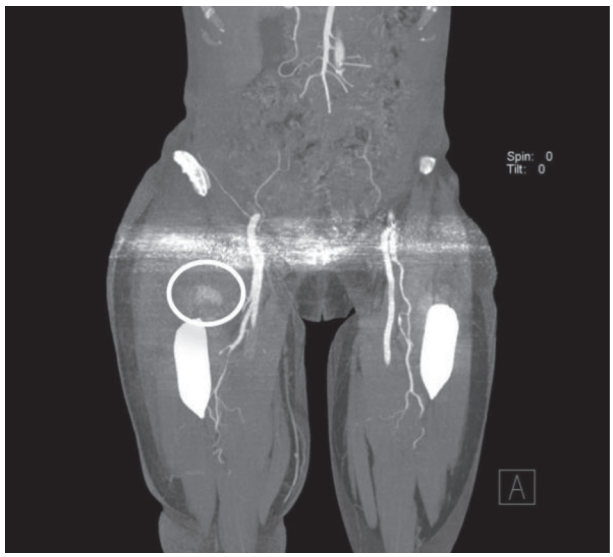

Figure 2. Active arterial bleeding on angio-CT scan

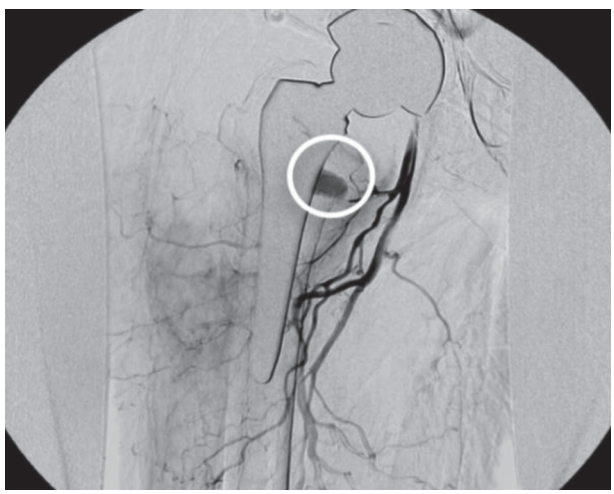

Figure 3. Active spreading of contrast solution at the right ascending femural circumflex artery on angiogram

Fig. 4). Through coaxial system with guide and microcatheter (Terumo Interventional Systems®, Somerset, NJ, USA) and by placing a two 2 and a 4 mm diameter spirals, embolization on the main branch of the ascending one of the lateral circumflex artery was performed. (Boston Scientific®, Marlborough, MA, USA) (Fig. 5). After this procedure, the introducer sheath was re-

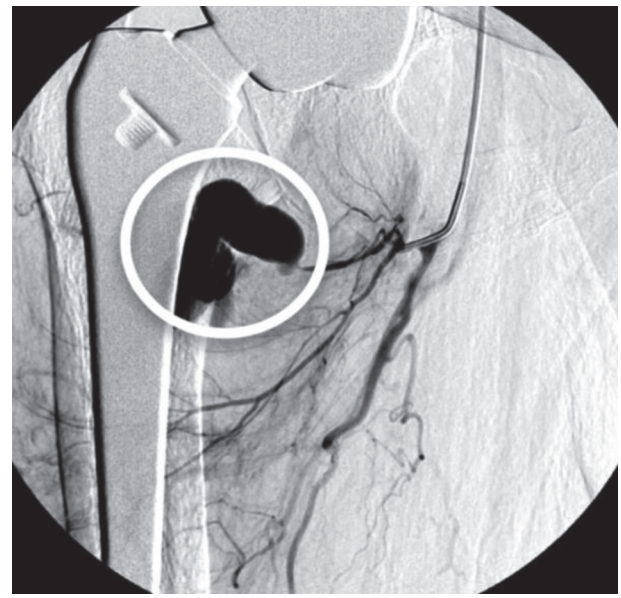

Figure 4. Active spreading of contrast solution at the right ascending femural circumflex artery on angiogram

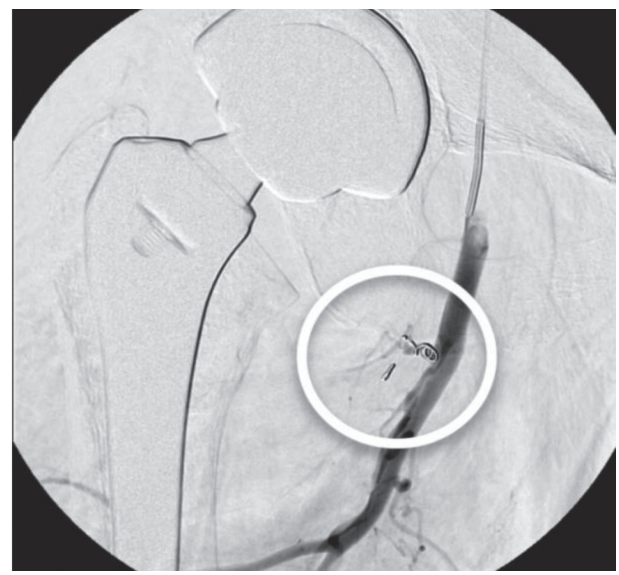

Figure 5. Spirals embolization on the main branch of the ascending one of the lateral circumflex artery

moved and replaced by an Angioseal (St. Jude Medical®, St. Paul, MN, USA).

Clinical revaluation in the days following the procedure, showed a positive outcome with a stabilization of the post-operative blood exams, the absence of further anaemia and a progressive local resolution of the clinical conditions.

Discussion

To prevent or minimize neurovascular injuries, which are one of the complications of hip arthroplasty, it is essential to have accurate knowledge of the anatomical structures and to recognize anatomical variants. During surgery, it is important to be cautious regarding excessive stretching, the utilization of the instrument which can easily cause damages, any bone cement leakage and the possible hematoma formation (6). Vascular injuries may manifest in many ways including bleeding, hemodynamic instability, presence of pulsatile mass, limb ischemia or occult blood loss. Any of these signs, isolated or combined, could represent a vascular injury, hence it should be considered an urgent angiogram (7). Color-Doppler ultrasound is the first level of Imaging method used to evaluate a vascular injury. CT scan and Magnetic Resonance Angiography are usually not applicable in joint replacement surgery because of the artefacts metal related. When non-invasive Imaging fails to reveal the injury, it is always required to submit the patient to an angiography. Endovascular treatments have been effective and safe interventional techniques in the acute or late postoperative period after elective orthopaedic surgery. In the case reported it is assumed a loosening of the ligature of the branch of the lateral circumflex occurred more than 20 days after the surgery with subsequent haemorrhagic spreading favoured by anticoagulant prophylaxis. These techniques should be considered as the first option in the treatment of these kind of lesions (8).

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Fracture of cobalt-crome modular neck in total hip arthroplasty

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Summary. Despite the advantages of modular total hip arthroplasty in terms of neck version, offset and length precise reproduction, titanium necks breakage became a concern. Consequently, titanium has been replaced by cobalt-chrome (Co-Cr). However, four cases of Co-Cr modular neck breakage have been reported in the literature. In the present paper, two cases of Co-Cr modular neck fractures are described together with a literature review. The aim of this work is to discuss the risk factors and characteristics of this rare complication. We described two cases of fracture of long varus Co-Cr modular femoral neck connected with cementless press-fit stem. Some risk factors, such as long varus type of modular neck, overweight and/or high demanding physical activity, might have contributed to implant failure. (www.actabiomedica.it)

Key words: cobalt-crome, modular neck fracture, total hip replacement, hip arthroplasty, risk factors

Background and aim of the work

Over the last decades, the use of modular total hip designs had a significant increase.

Modularity allows for greater versatility of the component with potential advantages in leg length discrepancy correction and optimal offset and anteversion reproduction. On the other hand, significant disadvantages have also been reported.

In particular, many cases of modular titanium necks breakage occurring at the base of the modular neck have been recently described, all associated with stress fractures caused by corrosion (1). As a consequence, titanium has been replaced by cobalt-chrome (Co-Cr) in modular necks (2). Nonetheless, modular neck breakage may remain a concern. One case of Co-Cr modular neck breakage was indeed described by Mencière et al. in 2014 (3) and three cases were reported by Kovac et al. in 2019 (4). Two cases of Co-Cr modular neck fractures are reported in the present paper together with a literature review. Aim of the paper is discussing the risk factors and characteristics of this rare complication. Both patients have given their approval to have their cases discussed in this paper.

Case 1

A 48-year-old man affected by degenerative hip osteoarthritis underwent primary total hip arthroplasty of the left hip in May 2011. The patient was overweight with a BMI of 28,02 (1.87 mt height, 98 kg weight).

A ProfemurL (Wright, Arlington, TN, USA) size 5 modular anatomical titanium (Ti64I4V) cementless stem was implanted on the femoral side, coupled with a cobalt chrome long 8° varus retro modular neck. A size 56 cementless press-fit Procotyl cup (Wright, Arlington, TN, USA) was implanted on the acetabular side. The bearing surface was ceramic on ceramic with

a Biolox Delta size 36 head. Postoperative radiographic control showed a correctly placed hip prosthesis, with a regular post-operative course. The patient resumed his daily activities without limitations or pain. In June 2015 (4 years postoperatively), the patient heard a crack from his left hip while he was jumping from a one-meter high wall. Thereafter, he referred severe hip pain with motion and inability to weight bearing on the affected limb. The patient came at the emergency department at our Institution, where left hip radiographs were taken demonstrating a fracture of the modular neck at the stem-cone junction (Fig. 1a). Both acetabular and femoral components seemed to be well fixed, and the femoral head remained attached to the proximal fragment of the modular neck. There were no clinical, radiographic or laboratory signs of infection.

After 4 days, the patient underwent revision total hip arthroplasty through a postero-lateral approach to the left hip. The modular neck fracture resulted to be complete with fragmentation at the stem-neck junction. Minimal fretting and corrosion damage on the surface that had mated with the femoral stem was observed (Fig. 1b). No macroscopic signs of metallosis were observed, thus no serum metal levels were obtained. Surgical intervention included femoral head and neck removal, accurate debridement of soft tissues and removal of the well-fixed stem through a Wagner femoral osteotomy. Finally, a cementless Lima Revision stem (Lima Corporate, Udine, Italy) with cerclage wires to stabilize the femoral osteotomy was implanted (Fig. 1c). The bearing surface was ceramic on poly with a Biolox Delta head size 36 head. Intraoperative microbiological coltures confirmed the absence of infection.

Case 2

A 77 -year-old man underwent primary total hip arthroplasty of the left hip for end-stage hip arthritis in 2011. He was overweight with a BMI of 28,73

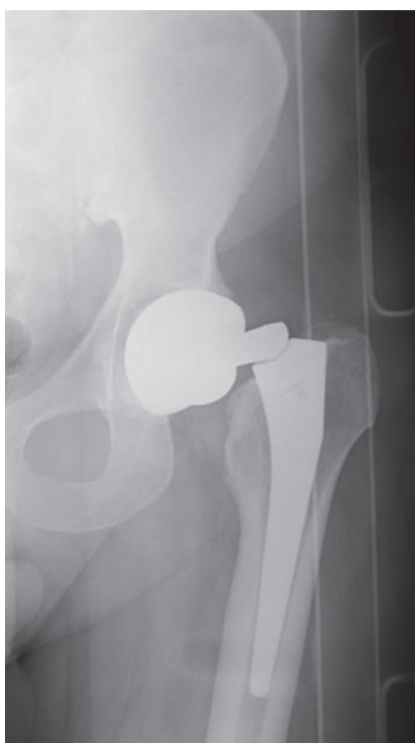

Figure 1a. Case 1. Left hip AP view radiographs showing a fracture of the modular neck at the stem-cone junction

Figure 1b. Case 1. Photograph showing the removed stem, neck and prosthetic head. A complete fracture of the modular neck occurring at the stem-neck junction is visible

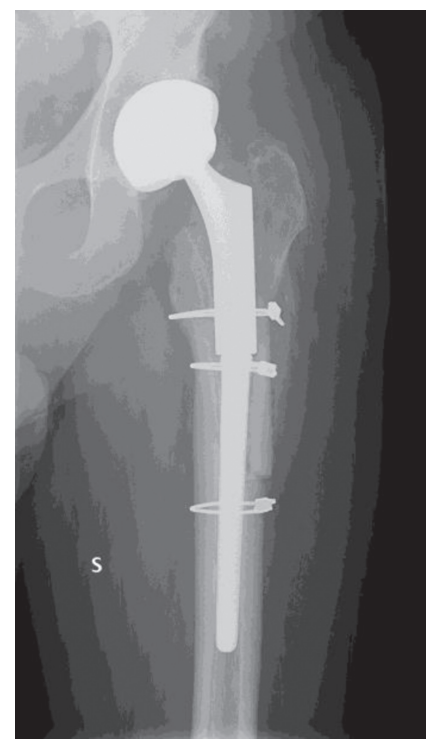

Figure 1c. Case 1. Left hip AP view postoperative radiographs showing implant revision

(1.76 mt height, 89 Kg weight). On the femoral side a Profemur (Wright, Arlington, TN, USA) modular anatomical titanium (Ti64I4V) cementless stem was implanted, coupled with a cobalt chrome long 8° varus modular neck.

Postoperative course was uncomplicated. After 4 years from the index procedure, the patient referred to the emergency department for acute left hip pain with a subjective feeling of instability, without any reported traumatism. Radiological evaluation showed a fracture of the modular neck at the stem-cone junction (Fig 2a). The acetabular and femoral components resulted to be intact. There were no clinical, radiographic, or laboratory signs of infection.

After 7 days, revision surgery was performed through a lateral approach. There were no macroscopic signs of metallosis, no iron particles or fibrosis were seen. Periprostethic soft tissue were free from relevant alterations, being the fracture of the neck the only pathological feature. The well-fixed stem was removed via a Wagner's osteotomy, and revised with a MP Reconstruction Prosthesis (Waldemar Link, Hamburg, Germany). Four cerclage wires were inserted to secure the osteotomy (Fig. 2b).

Discussion

Modularity in total hip arthroplasty has gained great popularity in the past, as it allows to restore optimal hip geometry, leg length, offset and anteversion of the prosthetic hip. Moreover, biomechanical advan-

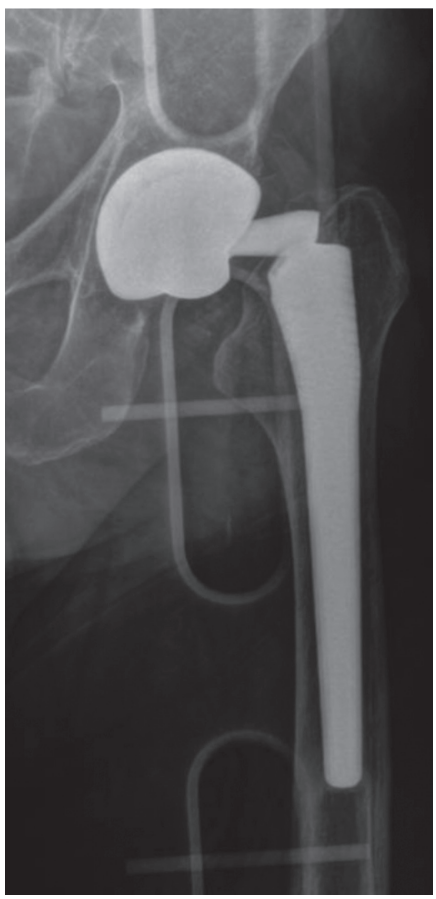

Figure 2a. Case 2. Left hip AP view radiographs showing a complete fracture of the modular neck at the stem-neck junction

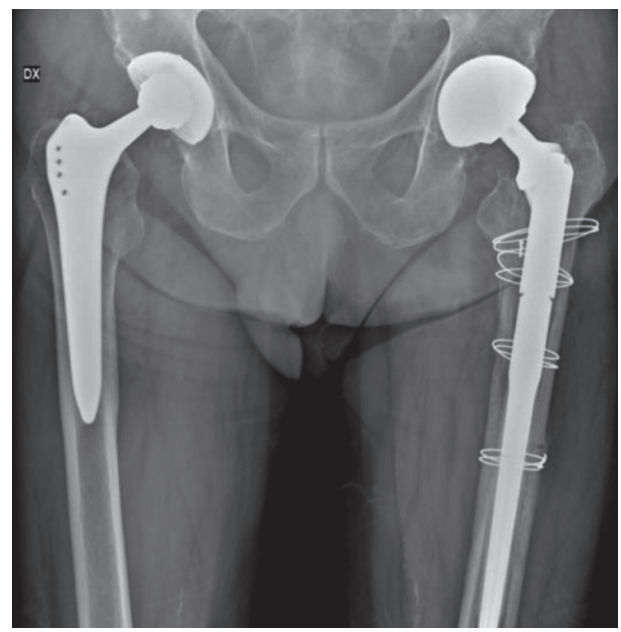

Figure 2 b. Case 2. Pelvic AP view post-operative radiographs showing implant revision of the left hip

tages such as wear reduction and impingement prevention have been described, with a theoretical reduction in dislocation risk (5-7).

However, fracture of the titanium modular neck-stem junction has been recognized as a major complication in these implants, consequently leading to implant failure. Many reports of titanium modular neck fractures can be indeed retrieved in the literature (8-10). The cause of mechanical failure has been ascribed to fretting, crevice and galvanic corrosion resulting in loosening of the modular junction and finally fracture of the implant (11). Corrosion and fretting occur both at the head-neck and at the neck-modular stem junction, augmenting with duration of the implant. Because of the lengthening of the lever arm and the subsequent higher mechanical stress, the degradation is mostly located at the neck-stem junction. Fretting and corrosion produce particles and ionic products that cause the release of inflammatory mediators and may contribute to the fracture of the implant (11-13). Because of the difference in the mechanical loads applied to the proximal and the distal junctions of the modular neck, fatigue fractures mostly start at the antero-lateral portion of the conical connection in titanium necks (2). Indeed, in the proximal junction there are compression forces, while distally there are tensile forces at the lateral part of the Morse taper and compression forces at its medial part. Particularly, in the distal junction this difference is caused by the moment of force produced by the length of the femoral neck and the weight of the patient (14).

Accordingly, both implant and patient related risk factors for titanium modular neck fracture have been reported in the literature. The main implant related factors are long varus neck, excessive neck ante/retroversion and metal-on metal coupling with large diameter heads, while the main patient related factors seem to be obesity and physical activity (15, 16). In order to reduce titanium modular neck fractures, Co-Cr modular necks have been introduced in clinical practice. In vitro, titanium modular necks have shown 38% less load bearing capacity and 72% decrease in fatigue resistance when compared with Co-Cr (2). Nonetheless, some authors suggest that sports and traumatic events may result in hip forces significant enough to potentially determine a fatigue fracture also of Co-Cr modular neck (17). At our knowledge, only 4 cases of Co-Cr modular neck breakage have been reported in the literature (3, 4). However, 3 more cases can be retrieved in the US Food and Drug Administration (FDA) adverse events database (18). Mencière et al. firstly reported a case of fracture of the Co-Cr modular femoral neck component in a 66 years old woman with a BMI of 28,7 kg/m^2, who received a modular THA as a result of hip osteoarthritis. A long, 8° varus modular Co-Cr neck was implanted and connected to a 36 mm short femoral head. The patient had a low level of physical activity and experienced no symptoms during the first 22 months. After this period of time, she felt acute pain in her hip during a physical exercise involving hip flexion and weight bearing. On the following day, she underwent a complete loss of function of the lower limb. The radiograph demonstrated a fracture at the stem-cone junction of the modular prosthetic neck, while the cup was intact. After that, she underwent surgical revision via a trans-femoral approach.

Recently, three more cases were reported by Kovac et al (4) in a multicentric study. Among 23 modular neck fractures registered in Slovenia between 2002 and 2015, three occurred in Profemur Z cobalt-chromium alloy modular necks (Wright, Arlington, TN, USA). The patients were male with a long varus neck. Their BMI was 30.7, 35.6 and 26. Time to revision surgery has been of 3.1, 3.2 and 2 years. No further descriptions are available.

The two cases of Co-Cr modular neck fracture reported in the present paper represent the third description in the literature for this rare complication. Some similarities with the other cases reported in the literature should be underlined. Indeed, a long varus modular Co-Cr neck was used in all the implants. In detail, the varus angle in both cases reported in the present paper was the same as the Mencière's case (8°). The fractures occurred at the stem-cone junction, that is the most reported breakage point in titanium modular necks too.

No previous traumatism had been reported. Moreover, the cases described by Mencière et al. and Kovac et al. studies involved overweight or obese patients as in the two cases reported in the present paper. Nonetheless, long varus type of modular neck and overweight and/or high demanding physical activ-

ity had already been reported in the literature as risk factors in titanium neck fractures. Moreover, clinical presentation was quite similar, with acute pain referred during weight bearing activities without any detectable trauma. Finally, the time lapse between prosthetic implantation and modular neck fracture was 2 to 5 years in all the reported cases.

In most titanium neck breakage cases described in the literature, prodromal symptoms such as groin pain and clicking sensations were reported to precede the fracture. Conversely, both in the cases described in the present paper and in the case described by Mencière et al. no prodromal symptoms were reported, suggesting a possible difference in Co-Cr neck fracture modality.

Summary

The two cases of Co-Cr modular neck fracture reported in the present paper represent the third description in the literature for this rare complication. In the present cases, long varus type of modular neck and overweight might have contributed to implant failure, as already reported in the literature.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Ceramic on ceramic total HIP arthroplasty and liner fracture. Two case reports and review of literature

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Summary. *Background and aim of the work:* Ceramic on ceramic bearing surfaces in total hip arthroplasty are rising in number with the purpose of reducing debris osteolysis in young patients. New generation ceramics drastically reduced the well known problem of liner's fracture associated with this material but this still represents a complication. *Methods:* We present the only two cases of acetabular liner fracture we had in our department, on a total of 252 patients, since we use CoC bearing surfaces in THR (2005-2019) analyzing symptoms and causes of this complication. Review of recent literature focused on symptoms and causes of liners fracture, well matched our cases. *Results:* In line with the analysis of literature, the major cause of liner fracture is neck-cup impingement resulting in the "edge-loading" effect, followed by other factors like prosthesis design, traumas and patient weight. From data also emerge the role of acoustic phenomena (e.g. squeaking) and CT scan in the diagnostic process. *Conclusions:* Last generation ceramics should be used in CoC THR, implant malposition and prosthesis design have a dominant role in liner fracture, squeaking should always be investigated. CT scan have an important role in diagnosis. Implant revision with substitution of the bearing surfaces is mandatory in case of fracture or impending fracture signs. (www.actabiomedica.it)

Key words: THR, ceramic, fracture, squeaking

Background and aim of the work

Ceramic-on-ceramic (CoC) bearing surfaces in total hip arthroplasty (THA) were developed with the purpose of reducing wear-induced osteolysis in young and active patients undergoing total hip replacement, thus theoretically decreasing the need for early aseptic loosening revision of the implant. Indeed, the use of other bearing surfaces routinely used in hip replacement surgery are demonstrated to produce a much higher rate of debris particles (1000 times more for metal-on-polyethylene and 40 times more for metal-on-metal surfaces(1)) and to be more related to bone resorption (2) around the implant than ceramic-on-ceramic surfaces. The typical low rate of debris production in CoC implants seems to be related to their extremely hard scratch-resistant surfaces and their hydrophilic characteristics that improve lubrication over the bearing surfaces (3).

A still present problem with this kind of implant, however, is the risk of liner and femoral head prosthetic fractures, though the introduction of new generation ceramics (e.g. Biolox-Delta®), decreased the rate of this complications to a 0,004% for femoral head and 1,12%-3,3% for liners (4-6).

Proposed causes of ceramic components fracture are the neck-cup impingement due to excessive acetabular cup anteversion especially during squatting, kneeling, and sitting cross-legged (5, 7, 8), dislocation, microseparation, trauma with implantation, and malposition of the implant (9, 10). In fact, the ideal abduction and anteversion angles for the acetabular cup appear to be respectively 45° to 55° and 10° to 15° (5), higher angles relating to neck-cup impingement.

The typical kinematics regarding neck-cup impingement seems to be referred to two mechanisms: the so called "edge-loading" effect, in which the contact between the neck of the femoral component and the edge of the cup produce the head subluxation on the opposite side causing a stress rise at this level where the fracture line starts; and a chipping ceramic mechanism due to repetitive neck-cup contact on the same side of the contact (11).

Clinical presentation of ceramic liner fracture can vary from audible noise (squeacking) during walking, or anyhow during active hip movement, to local instability, and in some cases can even remain undiagnosed for long time. Otherwise ceramic femoral head fracture is always a catastrophic event (12) presenting with acute pain and hip impairment.

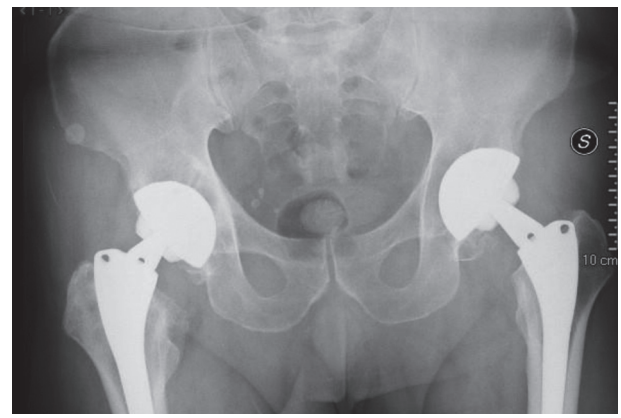
Investigation of a noisy-instable CoC THR should include standard pelvis and hip X-rays and a CT scan of the involved hip to detect any ceramic periarticular fragments or a major fracture line; and a needle aspiration of the articular synovial fluid to be analyzed looking for ceramic fragments around or >5 μm (12).

Considering the above, we review our CoC THR registry, looking for ceramic fracture cases, diagnostic process and treatment.

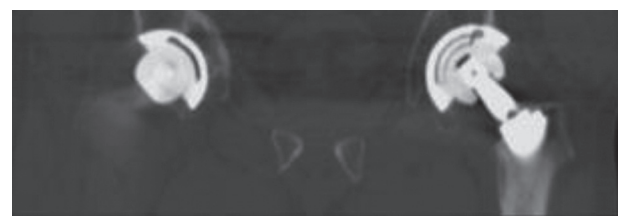
Materials and methods

We report the only 2 cases of ceramic fracture on a total of 252 patients treated with CoC THR in the period 2001-2019 in our department.

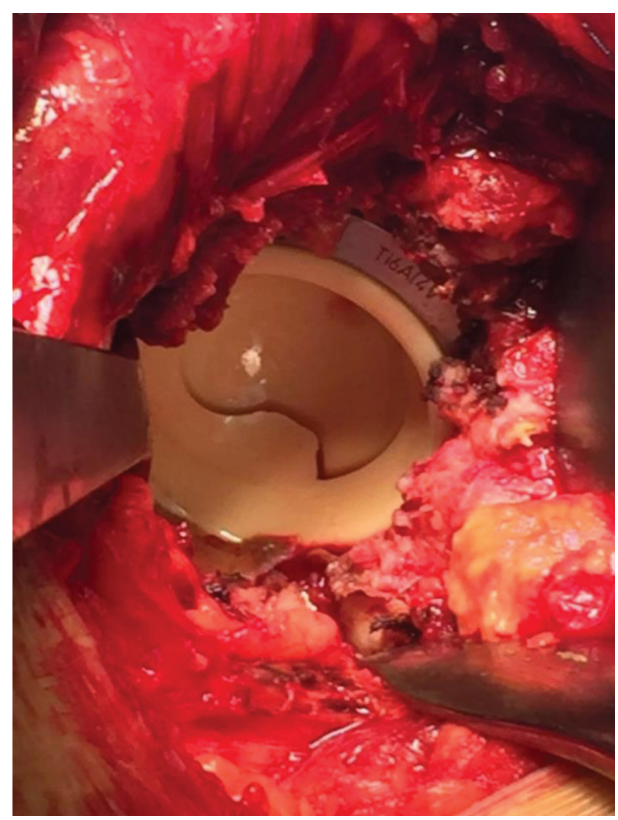
Case 1: 58 y.o. male with bilateral uncemented THR implanted 9 years earlier. He presented to us complaining a noise in the left hip began two weeks earlier apparently causeless and audible during walking and active range of motion of the interested hip, without any other symptoms like pain or swelling. Standard X-rays of pelvis and left hip were taken, without any sign of aseptic loosening or periarticular foreign bodies. A CT scan proved a fracture line involving the liner component. Revision surgery was then performed with substitution of femoral head and liner with a new generation ceramic of the same sizes. No chipping was



Case 1: no radiographic signs of periarticular ceramic bodies or aseptic loosening



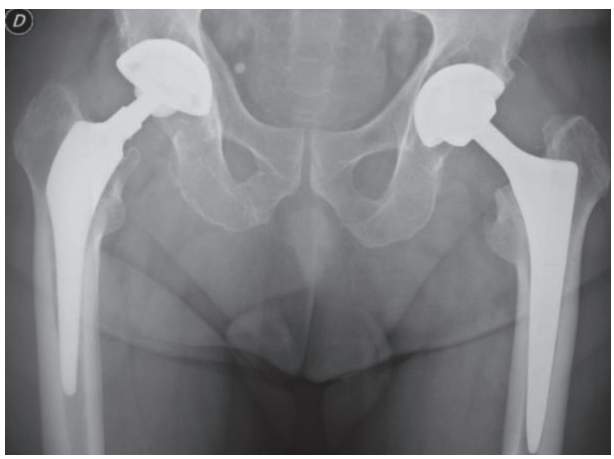
Case 1: TC sign of left THR liner fracture



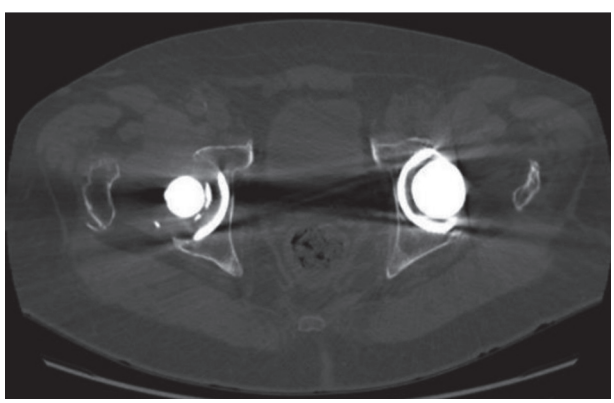
Case 1: intraoperative finding of left THR liner fracture

found on liner and no instability of the implant was present so we supposed the cause of fracture was the low resistance of the old generation ceramic used in the previous implant, allowing us to let the metal-back in place, verifying no neck-cup impingement after component substitution.

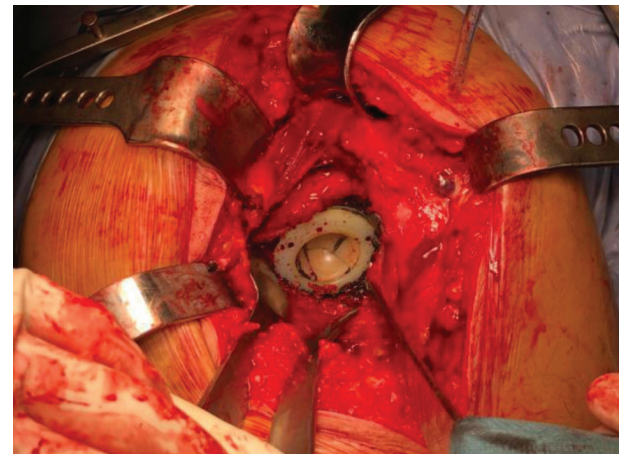
Case 2: 82 y.o. male with bilateral uncemented THR implanted 11 years earlier. He presented to us complaining noise and pain in the right hip during walking, began 6 weeks earlier apparently causeless. Also in this case standard X-rays of pelvis and left hip were taken, without any sign of aseptic loosening or periarticular foreign bodies. CT scan confirmed the suspect of a fracture line involving the liner component. Revision surgery was performed. Liner inspection revealed a moderate chipping on the opposite side



Case 2: no radiographic signs of periarticular ceramic bodies or aseptic loosening



Case 2: TC sign of right THR liner fracture



Case 2: intraoperative finding of left THR liner fracture

of the fracture line, and a corresponding mark on the femoral neck in the same position, demonstrating a low-grade neck-cup impingement. A substitution of femoral head and liner with a metal-on-polyethylene component was performed. We chose this option considering the age of the patient and his low-demanding condition at the time of surgical procedure, to reduce surgical related morbidity.

Results

Both patient healed without surgical related complications and returned to the previous activity level in a relatively short time: one month for the 58 y.o. man and 50 days for the 82 y.o. man. At long term follow-up (at least 2 years), we reported no limitations in daily life activity in both patient, with a complete return to his working activity for the youngest one. No new symptoms or signs like squeaking or pain were found in the revised hips.

Discussion and conclusions

THR can be considered a successful surgery and patient and surgeon satisfaction is growing up year after year with the improvement in surgical techniques and implant materials. Anyway complications, although decreasing in rate, are still present. A typical complication of ceramic-on-ceramic implants is ceramic frac-

ture, partially solved with the use of new generation ceramics, more durable and resistant to load; the other side of the problem however can be related to surgical technique errors like incorrect positioning of the acetabular cup, causing neck-cup impingement and subsequent abnormal loading of the bearing surfaces. In this regard, the ideal cup position seems to be 45° to 55° of abduction and 10° to 15° of antiversion (5). Audible noise during ambulation, like squeaking, should always alert the patient and the surgeon for possible ceramic fracture and an early diagnostic protocol consisting in X-rays, CT scan and synovial aspiration and analysis should promptly be undertaken. Hip revision surgery should be considered when a noisy CoC THR presents radiographic or synovial fluid signs of ceramic chipping or clear fracture lines (12).

Our experience with ceramic THR fracture is in line with similar cases reported in literature; in the here presented case reports we chose to revision the implants in a minimally invasive way, by the only substitution of the old compromised ceramic components with a new one in the first case and changing the tribologic setup to a more favorable one in the second case.

Our choice of a minimally invasive procedure depended on the absence of major impingement signs in the first case and in the advanced age of the patient (suitable for a metal on polyethylene implant) in the second one, also considering that the fractured ceramics belonged to an old generation material, allowing us to avoid a complete revision of the acetabular cup.

In case of major impingement signs otherwise a formal implant revision should be undertake.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Open patellar tendon avulsion from tibial tuberosity after ACL reconstruction successfully treated with suture anchors

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Summary. Patellar tendon rupture after anterior cruciate ligament (ACL) reconstruction is a rare complication which usually occurs in the early postoperative period during rehabilitation. The management of open avulsions from tibial tuberosity has not been clearly defined yet. We describe a previously unreported case of traumatic and open patellar tendon avulsion from tibial tuberosity one year following ACL reconstruction in an elite football player which was successfully treated with suture anchors. (www.actabiomedica.it)

Key words: patellar tendon, rupture, repair, anterior cruciate ligament reconstruction, postoperative complications

Introduction

Patellar tendon rupture after anterior cruciate ligament (ACL) reconstruction is a rare complication (0.06-0.24%) which usually occurs in the early postoperative period during rehabilitation programs (0-6 weeks) (1, 2). However, delayed injuries up to 10 years have been reported (3). Although ruptures of native, unharvested tendons are commonly in the proximal aspect, tears after ACL graft harvest occur both in a proximal or a distal pattern (2). We describe a case of traumatic and open patellar tendon avulsion from tibial tuberosity one year following ACL reconstruction in an elite football player. To our knowledge, this is the first report of an open tibial avulsion of the patellar tendon which was successfully treated with suture anchors.

Case report

A 23-year-old male elite football-player (180 cm x 80 kg, BMI 24.69) suffered an isolated tear of the right ACL in December 2010 as a result of a sports accident. The ACL was reconstructed using a bone-patellar tendon-bone ligament repair. Surgery and postoperative rehabilitation were uneventful, and the patient returned to elite football competitions after 8 months.

In November 2011, the patient was involved in a street accident (car against motorbike); he was catapulted falling onto both knees, and dragged on the street. On physical examination in the emergency room the patient had significant right knee effusion with a 10 cm long and deep wound below the patella. Standard radiographs revealed patella alta (Figure 1). Urgent CT scan excluded tibial plateau fractures, but avulsion of the patellar tendon from the tibial tuberosity was identified (Figure 2). The patient underwent immediate surgical repair. Examination under anesthesia of the knee revealed no varus or valgus instability, but Lachman test was positive. Accurate debridement and lavages were performed.

The tendon was found to have avulsed from the tibial tuberosity (Figure 3), and the proximal aspect of the tendon appeared attenuated and degenerative in nature; moreover, no fibers remained connected to the tibial tuberosity. To re-fix the tendon to the native

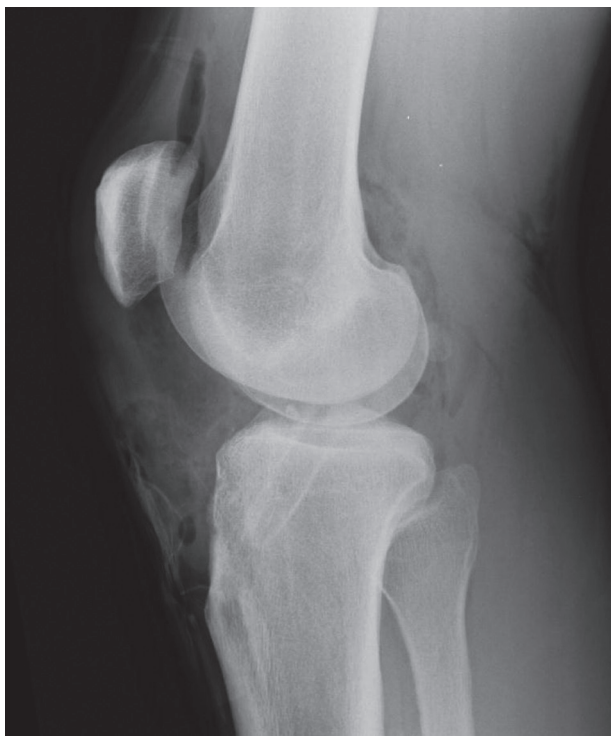

Figure 1. Post-traumatic standard x-ray showing patella alta

place, trans-osseous sutures were excluded because of the risk of an excessive bone defect and weakness due to presence of multiple holes close to the tibial tunnel of the ACL reconstruction.

We established to fix the tendon using three suture anchors ("Super Quick Anchor Plus" DePuy Orhopaedics, Warsaw, IN, USA, and "LINVATEC Super Revo" CONMED Corporation, Largo, FL, USA). Stability was manually tested through forceful pulling on the anchor to ensure that pullout could not occur. Reconstruction was reinforced with multiple wire loops because of the risk of further damage (Figure 4). The treatment of ACL tear was delayed to prevent joint stiffness and the risk of infection.

Immediate postoperative x-ray showed normal patella position (Figure 5). Knee brace in full extension was used for four weeks, followed by a gradual increase of the joint range of motion. In January 2012, ten weeks after injury, the patient returned to full-time work and continued rehabilitation programs. In May 2012, 6-month follow-up showed complete range of motion of the knee joint with no pain, and CT scan revealed appropriate tendon reconstruction (Figure 6).

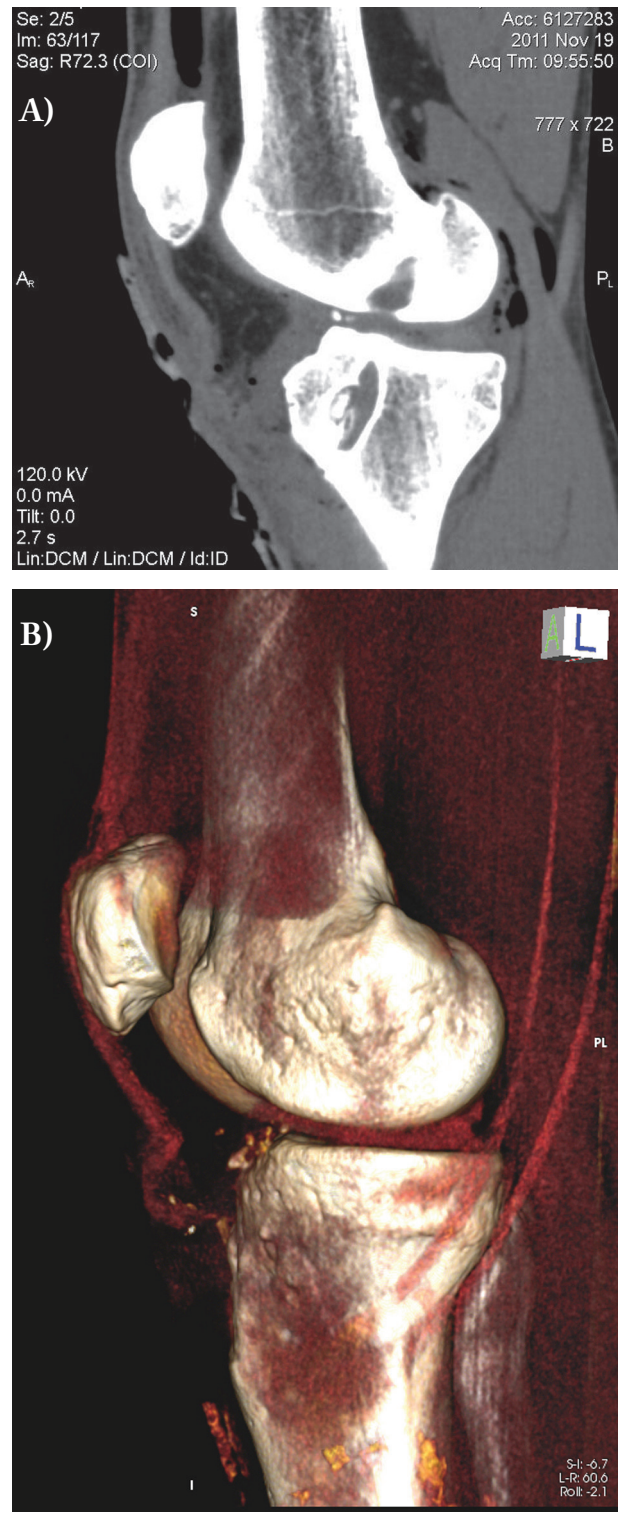

Figure 2. Urgent CT-scan, sagittal image [A] and 3D reconstruction [B], demonstrating patellar tendon avulsion from the tibial tuberosity

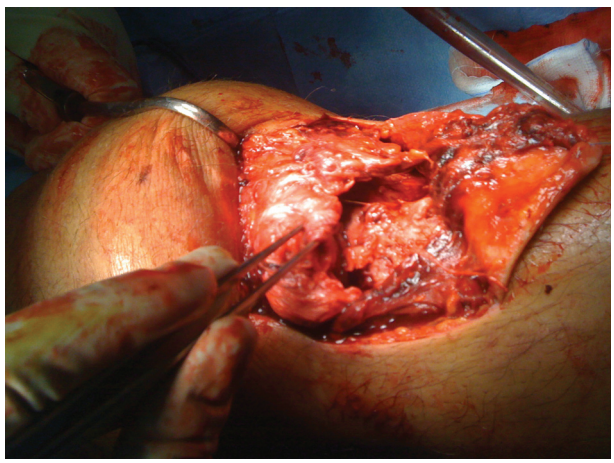

Figure 3. Preoperative evaluation revealing complete distal avulsion of the patellar tendon from the tibial tuberosity

In August 2012 the patient underwent further ACL reconstruction in another hospital with contralateral hamstring graft with good functional recovery. Return to football competitions was allowed eight months later, in April 2013.

Discussion

Ruptures of the patellar tendon are uncommon after ACL graft harvest (0.06-0.24%) (1, 2), as biomechanical analysis concludes that the remaining two thirds of the patellar tendon should be more than sufficient to resist rupture during quadriceps contraction under considerable loads (4). Moreover, the remaining tendon undergoes an ongoing histologic process of maturation that includes thickening and increased collagen fibril size, as well as hypercellular deposition (5). Although they are early postoperative complications, delayed injuries up to 10 years have been described (3), and usually occur in either a proximal-medial and distal-lateral pattern or an entirely distal pattern (6).

Whilst nonoperative management of a partial tear may be advocated, resulting in a rapid functional recovery (6), complete tendon lesions require surgical repair.

Lee et al. reviewed data related to 1725 consecutive patients who underwent primary ACL reconstruction using bone-patellar tendon-bone autograft and found only 1 case of patellar tendon rupture (1).

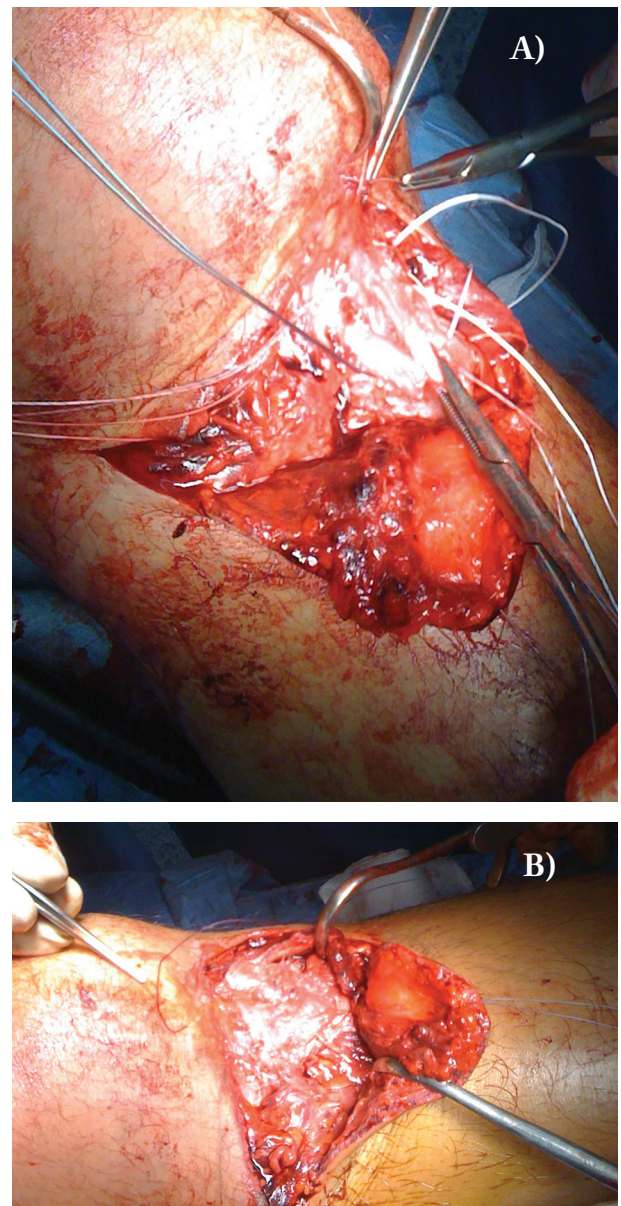

Figure 4. Intraoperative views showing initial [A] and final [B] re-fixation of the avulsed tendon with suture anchors

The patient, a 42-year-old police officer, slipped on ice 4 weeks postoperatively suffering a hyperflexion injury, and sustained a distal rupture of the infrapatellar tendon. The surgical procedure involved repair with a double layer Bunnell suturing of the tendon ends, reinforced with double-bundle hamstring autograft, as well as figure-of-eight tension band technique using an 18-gauge wire. Four months later removal of

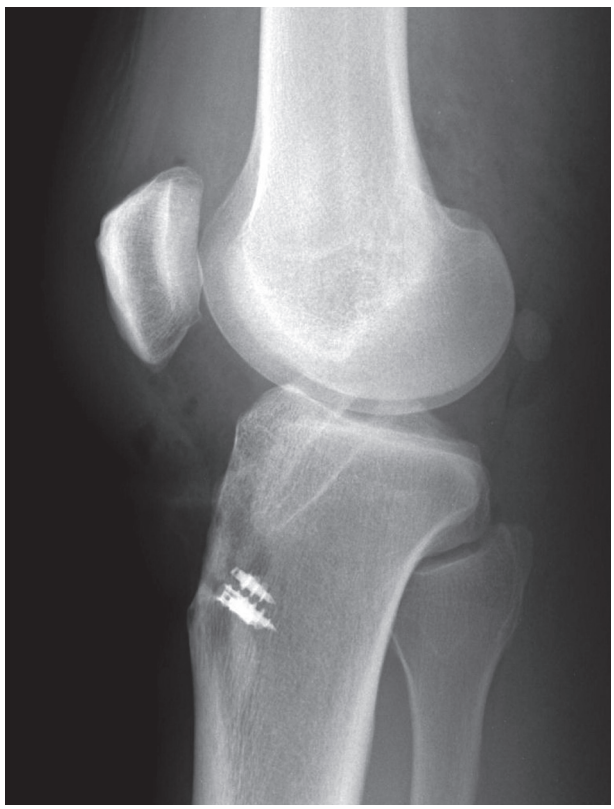

Figure 5. In the immediate postoperative check, restoration of proper patella level and correct positioning of titanium suture anchors are evident

the hardware was required. In a large series of 5364 ACL reconstructions published in 2012, Benner et al. reported 13 patellar tendon ruptures up to 56 days after surgery, for an incidence of 0.24% (2). Tear pattern differed from the usual proximal-only tear which is most commonly observed in unharvested tendons. Seven of 13 ruptures occurred from the patella origin medially and the tibial insertion laterally. Surgical repair was performed using suture anchors which were placed in the patella and/or the tibia depending on the site of lesion. A Dall-Miles cable was finally passed through both patella and tibia with no soft tissue augmentation. Immediate postoperative mobilization was started, and an immobilizer was required during ambulation only, maintaining a full weightbearing status. The Dall-Miles cable was removed 2 to 3 months after tendon repair when limiting the flexion.

Ouweleen and McElroy previously documented the Z-type tear pattern (7), and 2 additional cases of complete distal tendon ruptures were reported (4, 8).

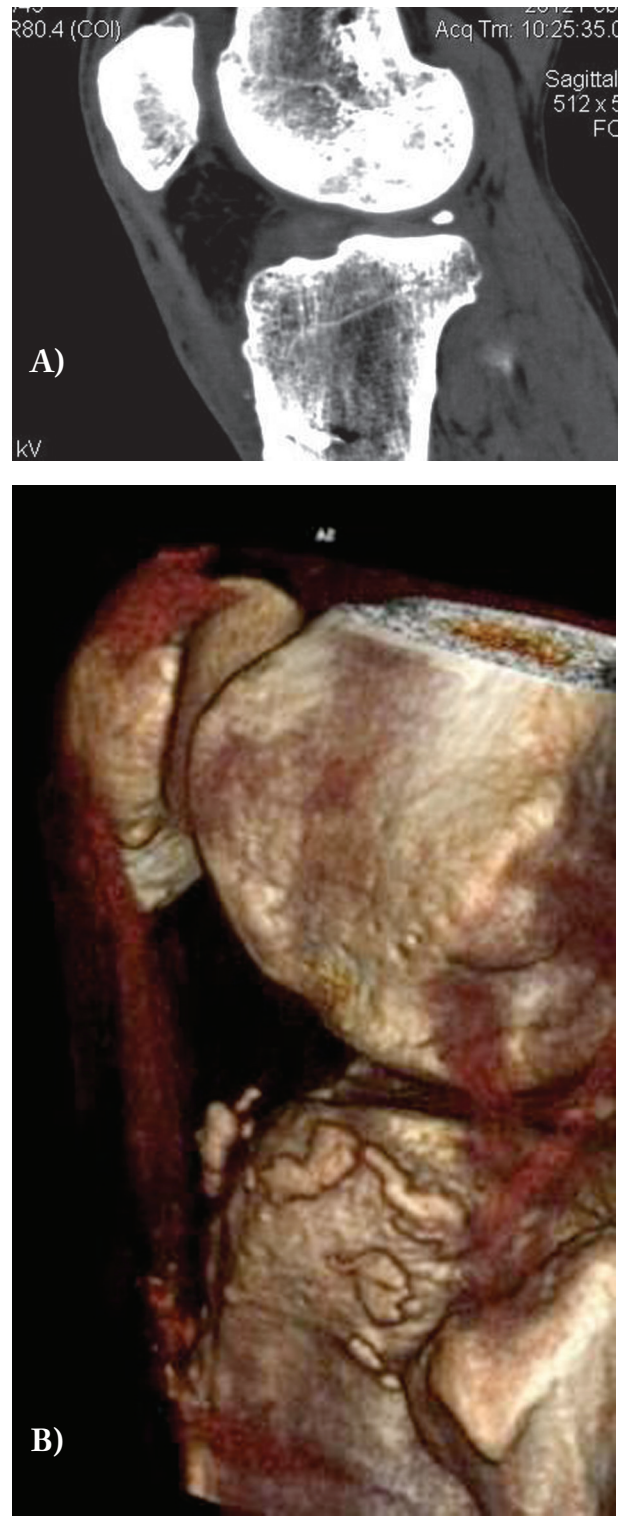

Figure 6. Six-month CT-scan, sagittal image [A] and 3D reconstruction [B], demonstrating appropriate tendon repair

As the Z-type tear pattern leaves 2 bony attachment sites, it can be successfully treated without soft tissue augmentation. Conversely, complete detachment from the tibia is normally managed by using transosseous tunnels. Successful repair using a bone-tendon-bone (BTB) allograft followed by a multiple-wire loop reinforcement with no postoperative immobilization was described in a professional handball player by Milankov Ziva et al. (9). A simultaneous reconstruction of both ACL and avulsed patellar tendon has also been reported, and reattachment of the anterior tibial tubercle using a cerclage wiring technique was performed satisfactorily (10).

In comparison with previously published cases, our patient presents several peculiarities. First, the mechanism of injury, as the rupture occurred following a fall during a street accident. Second, the associated recurrence of ACL rupture. Third, the large opening of the lesion, which required an urgent treatment. Finally, the innovative surgical solution.

Due to the high risk of infection related to the open injury, repair of the concomitant lesion of the reconstructed ACL was delayed. However, when completed emergency checks, an urgent surgical treatment of the avulsion of the patellar tendon was carried out.

Many surgical techniques for acute restoration of patellar tendon disruptions have been described. Repairs of the tendon to bone may be augmented with a Dall-Miles cable, Dacron sutures, neutralization and cerclage wires, autogenous semitendinosus graft, and BTB allograft (11).

Trans-osseous re-fixation of the tendon to the tuberosity was primarily excluded because of the possible bone weakness induced by multiple holes close to the tibial tunnel of the ACL neoligament.

Suture anchor fixation in patellar tendon avulsion is an excellent technique that enables strong anchorage with minimal dissection and eliminates possible complications associated with alternative procedures (12). Finally, effective healing and relatively fast return to functional activities are to be expected compared with the intra-osseous suture technique (13).

Use of the titanium anchors has several advantages: excessive shortening is prevented because the tendon edges do not penetrate into the bone tunnels, and loosening or expansion is not an issue. Furthermore, the periosteal dissection is less aggressive as complete exposition of the tibia is not required. Therefore, this technique prevents the need for additional surgery, although the removal of hardwares can be considered a minor procedure.

Finally, the use of suture anchors proved out to be an effective technique for the treatment of patellar tendon rupture from tibial tuberosity following ACL reconstruction.

In conclusion, patellar tendon rupture is a rare complication following anterior cruciate ligament reconstruction. Surgical repair of traumatic and open patellar tendon avulsion from tibial tuberosity following ACL reconstruction in an elite football player can be successfully treated with suture anchors, allowing early rehabilitation and complete sports recovery.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Case report

Traumatic extensor tendons injuries of the foot in childhood: a case report

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Summary. *Background and aim of the work:* Extensor tendon injuries of the foot in children represent a rare foot injury. We report a case of a 9 year-old male who suffered of a traumatic wound laceration in the distal third of the right leg with a glass the day before in another country, getting a combined injury of tibialis anterior (TA), extensor hallucis longus (EHL) and extensor digitorum longus (EDL). *Methods:* After an initial clinical and radiological evaluation, antibiotic prophylaxis was immediately started. Surgery was necessary for the repair of the lesions and after rehabilitation the patient recovered a good function with a complete return to a normal life. *Results:* 5 years follow-up clinical examination revealed a complete and painless range of movement comparable to the other foot. The patient regained active dorsiflexion without functional limitations, deformity or contracture. *Conclusions:* Early exploration is important to allow full definition of the extent of injury and early surgical repair of tendons is recommended to avoid future disability. (www.actabiomedica.it)

Key words: extensor tendons, foot, children, injury, rupture

Introduction

The extensor tendons of the foot are vulnerable to laceration because of their subcutaneous. They may be cut when a sharp object lacerates the skin and underlying structures. This kind of injury usually results in a high-stepping, drop-foot gait with weakness of ankle and toes dorsiflexion (1, 2).

Early diagnosis is emphasized, but often it can be confusing and is delayed. Special diagnostic studies, including magnetic resonance imaging (MRI) and sonography can help to estabilish an accurate and prompt diagnosis. Anyway, routine exploration of all dorsal foot and ankle wounds should be performed if there is suspicion of partial or complete tendon laceration. Surgical intervention is often necessary to repair these lesions. These structures heal well and have minimal dysfuction when repaired acutely. While operative management would seem to be indicated in most patients, it is important to consider potential complications from surgery, such as painful scar and joint stiffness from tendon adhesions. Thus, a specific rehabilitation and a close collaboration among different specialists are ultimately required in order to avoid these complications and to return to preinjury status (1, 3-5).

Case report

A 9-years old male came to our emergency department as consequence of inability to move the right foot. Mother told that he injured his right leg with a glass the day before in another country, where the wound was sutured. At the moment of the hospitalization the patient had a cutting wound localized in

the anterior distal third of the right leg. Patient was regularly vaccinated against tetanus. In the emergency room an X-ray, an ultrasound and a magnetic resonance imaging (MRI) were done and a total laceration of TA, EHL and EDL was diagnosed. There were no fractures associated. The day after (two days following the traumatic event) surgical repair was performed. Antibiotic therapy with trimethoprim and sulfamethoxazole was administered during hospitalization.

Surgical technique

The patient was placed in the operating room in the supine position, and an ipsilateral thigh tourniquet was applied. The stitches were removed and exploration of the wound was performed (Fig. 1). Tibialis anterior, extensor hallucis longus and extensor digitorum were interrupted. A "Z" extension of the wound was performed and the proximal tendon stumps were found 5 cm proximally. After, the extensor retinaculum was transacted (Fig. 2) and the distal stumps were found (Fig. 3).

An end-to-end suturing was still possible. TA tenorrhaphy was performed with 3.0 nylon suture wire and overcoat with nylon 5.0, tenorrhaphy of extensor hallucis longus with nylon 3.0 and overcoat with nylon 5.0 and suture of extensor digitorum with 3.0 nylon and overcoat with 5.0. All the surgical tendon repairs were performed according to the modified Kessler technique.

The exploration of anterior neurovascular bundle showed no lesions of the nerve and vascular complete interruption. Vein and artery were micro surgically repaired. The extensor retinacolum was then sutured and the skin was closed in layers. A non–weightbearing removable long leg cast was applied to the lower

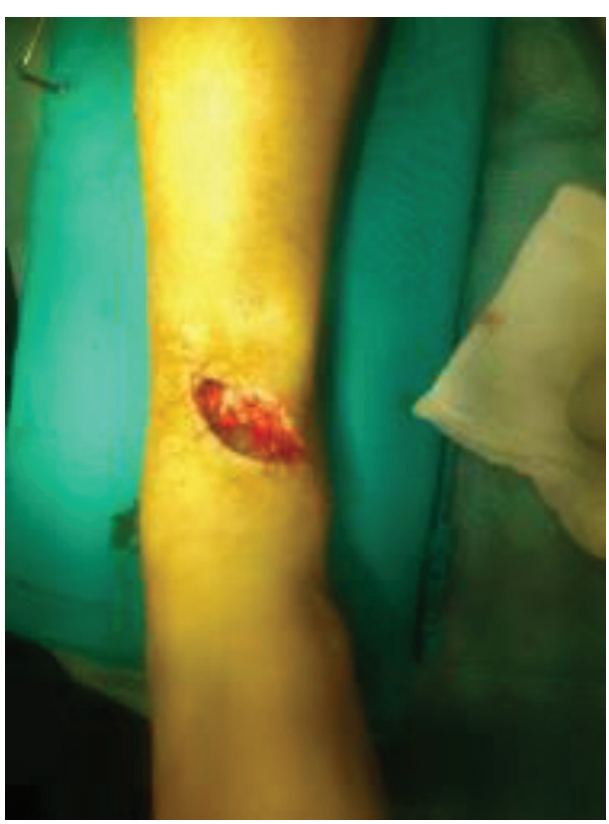

Figure 1. Wound after stitches removal

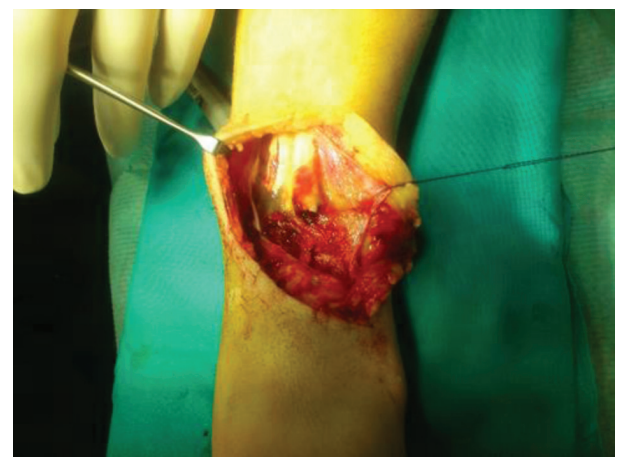

Figure 2. Opening of the extensor retinaculum

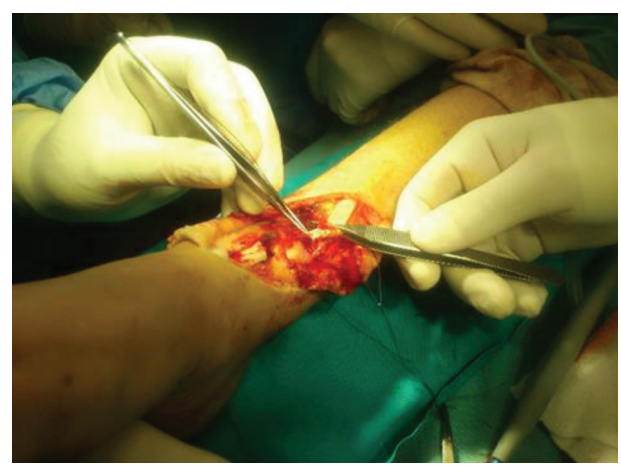

Figure 3. Recognition of tendon stumps

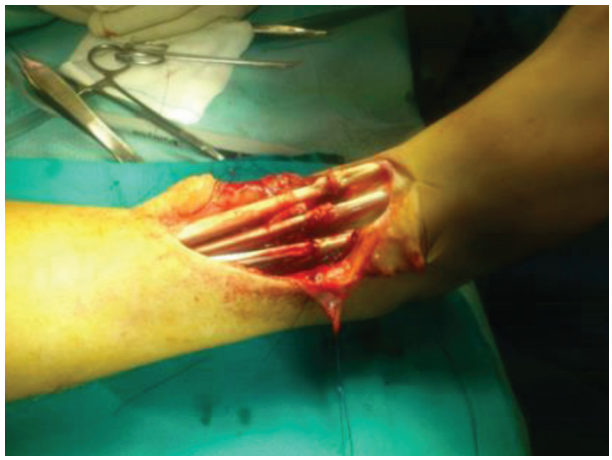

Figure 4. Tenorraphy according to modified Kessler technique

extremity at the conclusion of the procedure with the knee in flexion of 45° and foot at 90° and slightly in talar position.

Postoperative care and outcomes

The patient was discharged the day after surgery. Patient's postoperative course involved placement in a removable long-leg cast splint for a period of 4 weeks, during which he was not allowed to weight bear. In this period passive assisted dorsiflexion was permitted.

At the following outpatient visits the wound healed well and the stitches were removed after 15 days. After leg cast removal, the patient started idrokinesis and active rehabilitation in order to recover range of motion (ROM) at the ankle joint and first metatarsal-phalangeal joint. Six weeks postoperatively weightbearing was allowed. After two months and half foot and ankle motility was normal and the patient returned to practice his sport activities. The evaluation 5 years after surgery showed that the scar was good without retraction of the skin, pain was absent and active motion of the foot and toes was complete (Fig. 5). Furthermore, he reported to be satisfied with the surgical outcome and he actually he is playing in a soccer team.

Discussion

Extensor tendon ruptures of the foot represent about 1% of all tendon injuries (6). Lacerations from glass are an important cause of lesions in childhood with high risk of severe soft tissues damages. Frequently, a simple skin wound disguises the extensive nature of the injuries beneath (7). Early diagnosis and surgical repair of the tendons are recommended to avoid future disability (8,9) especially in young active patients with high functional demands. Nonsurgical manage-

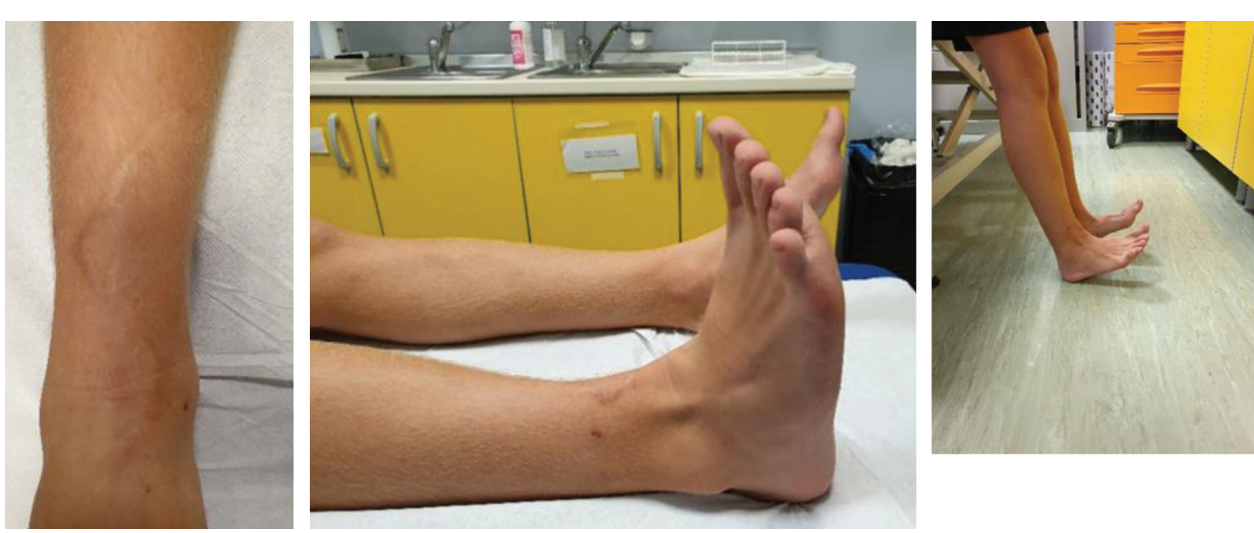

Figure 5. Follow-up after 5 years; scar, complete extension of the right foot that is equal to the contralateral one

ment could be an appropriate alternative in selected low demanding elderly cases (10). A decrease in ankle joint motion and strength, heel cord contracture, ankle osteoarthritis and pes planus have been described in cases of untreated ruptures (11, 12).

In fact the muscles of the anterior compartment of the leg (tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius) are important in order to dorsiflex the ankle and toes and to control the forefoot during the swing phase of gait. Injuries of these anatomical structures and of the anterior neuromuscular bundle may lead to pain, weakness, and drop foot (1).

Primary repair of tendon is possible when their severed ends can be closely approximated, as in our case; however, when primary repair is not possible, a tendon graft will probably be required (13).

In addition to the clinical examination, MRI and also ultrasonography are useful in the diagnosis. Moreover, both can be helpful in evaluating the location of the rupture and the quality of the remaining tendons and the entity of their retraction (14-16).

During the exposure of the tendon, when possible, the superior extensor retinaculum should be left intact, because this structure at the level of the ankle is often thin, and its repair can be difficult. Adhesions of the repaired tendon to the retinaculum are common and difficult to avoid because of the immobilization required in the postoperative protocol. In patients with comorbidities, such as diabetes and chronic vascular insufficiency, the retinaculum may not be repairable, possibly leading to subcutaneous adhesions, bowstringing of the tendon, and wound healing problems (1).

After surgery, the patient has to be immobilized at 0 degrees of plantarflexion; in fact the position of the tendon after repair should be neutral, leaving it without tension. Passive assisted dorsiflexion can be allowed, thus facilitating tendon remodelling and joint motion and avoiding tensioning of the repair zone (1). After a 4-week period of non weight bearing and immobilization, active rehabilitation and progressive assisted walking can be started. Authors believe that a correct postoperative management, programmed based on patient characteristics, is equally important in order to restore a physiological ROM, strength and function.

This case report confirms this assumptions; the young age of the patient suggested to do a less aggressive rehabilitation and to delay the concession of the load. Furthermore, a long chalk was applied in order to discourage him from walking but usually in an adult, a short leg splint is enough (17,18).

Conclusions

Wound exploration in penetrating glass injuries is mandatory. MRI and ultrasound can be useful to confirm the diagnosis and for a preoperative planning. It is preferable to operate this kind of lesions as soon as possible in order to prevent excessive retraction of tendon stumps. In high demanding patients, an anatomical reconstruction and an accurate postoperative management and rehabilitation protocol are essential.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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