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Original article

# The SMR reverse shoulder arthroplasty in rotator cuff arthropathy management

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**Summary.** *Background and aim of the work:* Cuff tear arthropathy (CTA) is a well-defined degenerative pathology of the shoulder. When conservative treatments are unable to permit a good quality of life, the reverse shoulder arthroplasty (RSA) can guarantee a good restitution of range of motion, function and strength of the shoulder without pain. In this paper we show our clinical, functional and radiological outcomes, as well as complications of RSA in patients with CTA. *Methods:* We analyzed 31 patients who underwent to reverse shoulder replacement with Modular Shoulder System (SMR, Systema Multiplana Randelli; Lima-LTO, San Daniele del Friuli, Italy) reverse shoulder system, between August 2010-July 2014. *Results:* A significant improvement in ROM and functional scores (Constant Shoulder Score and UCLA score) were observed in our cases series. At the time of follow-up pain relief was detected in 28 patients and 3 patients declared mild pain. Overall, 90.3% of patients rated their satisfaction as good or excellent. Although complications occur in a high percentage of patients in literature, no postoperative complications was observed in our cases series. *Conclusions:* Our results showed how reverse shoulder arthroplasty is a real solution to improve quality of life, to restore pain-free ROM, function and strength of the shoulder in patients where cuff tear arthropathy occurs. (www.actabiomedica.it)

**Key words:** reverse shoulder arthroplasty, cuff tear arthropathy, outcomes, ROM, scores, SMR, scapular notching

## Background and aim of the work

The shoulder is the most mobile joint in humans often affected by various conditions with concomitant or pre-existing rotator cuff deficiency (1). Nowadays, it's clear how a massive cuff tear can determinate a drastic biomechanical alteration and loss of shoulder stability. After a rotator cuff tear, forces and motion vectors are modified, resulting in humeral head lift to the acromion. Moreover, anatomical rotation fulcrum of the humero-scapular joint is also altered. In this clinical framework, articular cartilage surface undergo to structural alterations, and a new joint is formed between humeral head and acromial arch. Eccentric osteoarthritis is the final progression of these alterations, characterized by severe pain, night pain, pseudoparalytic arm and unable to live independently. Neer, in 1983, called this disorder "cuff tear arthropathy" (CTA) (2) and it rappresents a very disabling disorder for patients. The incidence of cuff tear arthropathy is about 2% in patients over 80 years of age (3). Currently, cuff tear arthropathy is a well-defined pathology characterized by the association of gleno-humeral joint arthritis and a massive rotator cuff tear. According to the Seebauer classification, the shoulder joint may remain concentric (type 1) or the humeral head may migrate superiorly (type 2). Often it is accompanied by an antero-superior migration of the humeral head (4). Besides, Hamada et al. (5) in their classification grade this disorder with the acromiohumeral distance, concavity of the acromion, gleno-

humeral joint space and collapse of the humeral head. Although a conservative treatment should be always tried in early cuff tear arthropathy (6, 7), shoulder joint replacement can guarantee a satisfying joint function restoration and pain relief in many cases. In particular, the 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 (MIRCT) and CTA (8-10). This prosthesis is characterized by a non-anatomical design (Fig. 1), that medializes the rotational center, refining the deltoid muscle's lever arm and intrinsic stability of the implant in the absence of a functioning rotator cuff (increasing deltoid efficiency) and reducing mechanical torque at the glenoid component (decreasing glenoid loosening) (11, 12). Indications to this system include rotator cuff arthropathy, massive rotator cuff tear, severe proximal humeral fractures, and revision after failure of previous total shoulder arthroplasty or hemirthroplasty (8, 13-17). The original indication for RSA was cuff tear arthropathy, but the success of this implant has led to extend the indications in other disorders where rotator cuff is missing. Several studies in the early phase of familiarization with the technique show few cases of RSA for rotator cuff arthropathy or had cases with mixed pathology. In the last ten year relevant innovations in implant design and technique have led many companies to introduce their new version of the original design proposed in 1985 by Grammont (i.e. Aequalis Reversed Shoulder, Tornier, Saint Ismier, France and the SMR Shoulder,Lima,Udine, Italy). As a result the procedure now is widely executed in mainland Europe (3). In this paper, we analyzed the short outcomes in patients who underwent reverse shoulder arthroplasty only for cuff tear arthropathy with SMR Modular Shoulder System (Systema Multiplana Randelli; Lima-LTO, San Daniele del Friuli, Italy) (18) (Fig. 2).


**Figure 1.** Biomechanical changes after reverse total shoulder arthroplasty: the rotation center located on the glenoid surface protects it against excessive shearing forces and the humerus is lower. (L = lever arc of the force vector (F) and the deltoid (Δ))

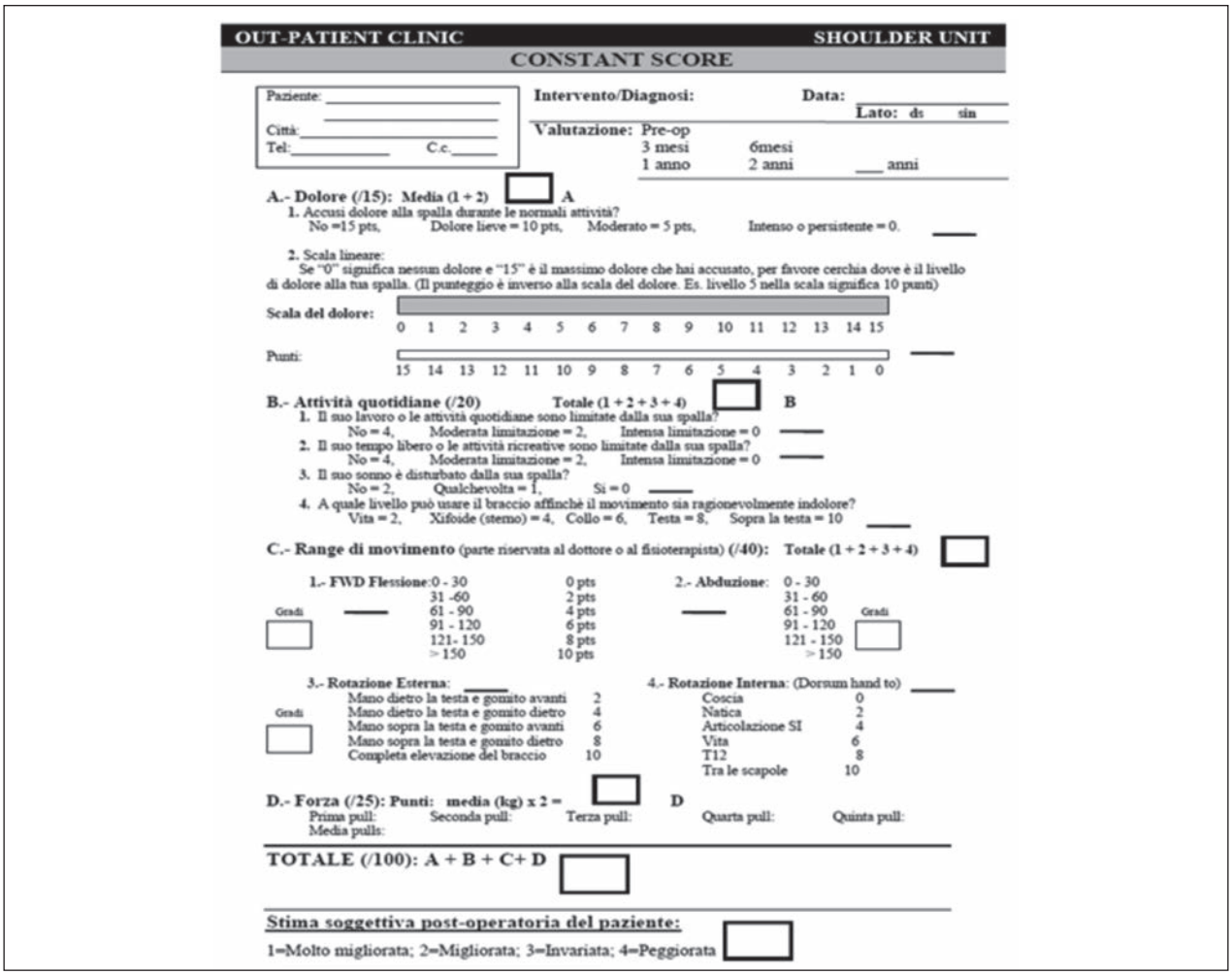
**Figure 2.** The SMR Reverse system.
Foto modificata from https://limacorporate.com

## Methods

Between August 2010 - July 2014, 33 reverse shoulder arthroplasty were performed at our institution (Clinic of Orthopaedics, Academic Hospital of Udine). SMR® Lima Corporate was implanted in all patients by the same surgeon. Cuff tear arthropathy was diagnosed in all patients. We started this retrospective analysis between 2 and 4 years after the surgery. Two patients died for unrelated causes to the shoulder re-

placement before our study began, so we included in this paper 31 patients (7 males and 24 females). SMR reverse shoulder prosthesis (Systema Multiplana Randelli; LIMA, Udine, Italy) was implanted in all patients. This system is a modular implant that consists of the humeral stem, the reverse humeral body and the reverse liner. Due to its modularity, different combinations is allowed; infact it is possible to adjust the diameter of glenosphere (30, 36, 44 mm), the angle of retroversion, the implant height and the eccentricity of glenosphere (6). Deltopectoral approach was performed in all patients seated in beach-chair. Tenotomy of the long head of the biceps tendon (LHBT) was executed in patients in whom it was intact and its tenodesis was performed at the pectoralis major muscle in 29 cases (in 2 cases LHBT wasn't found for previous tear) (18). In the post-operative time shoulders was immobilized by simple brace for 3 weeks. Only passive mobilization was granted. After this period, patients started active assisted rehabilitation program. Physical and radiographic assessment was performed in the early post-operative time and during follow-up at 1, 3, 6 and 12 months after surgery. During physical evaluation, active and passive shoulder range of motion (ROM) was recorded in elevation, abduction, external and internal rotation. Internal rotation was reported as the vertebra that the patient can reach with the hand keeping the elbow flexed to 90° (19, 20).

Pain relief was recorded by visual analogue scale (VAS). Functional outcomes were measured by use of the Constant Shoulder Score (21) (Fig. 3) and The University of California Los Angeles (UCLA) shoul-


OUT-PATIENT CLINIC SHOULDER UNIT

CONSTANT SCORE

Paziente: _____ Intervento/Diagnosi: Data: _____

Città: _____ Lato: ds sin

Tel: _____ C.c. _____ Valutazione: Pre-op 6mesi

3 mesi

1 anno 2 anni ___ anni

A.- Dolore (/15): Media (1 + 2) ☐ A

1. Accusi dolore alla spalla durante le normali attività?
No =15 pts, Dolore lieve = 10 pts, Moderato = 5 pts, Intenso o persistente = 0. ___

2. Scala lineare:
Se "0" significa nessun dolore e "15" è il massimo dolore che hai accusato, per favore cerchia dove è il livello di dolore alla tua spalla. (Il punteggio è inverso alla scala del dolore. Es. livello 5 nella scala significa 10 punti)

Scala del dolore: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Punti: 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 ___

B.- Attività quotidiane (/20) Totale (1 + 2 + 3 + 4) ☐ B

1. Il suo lavoro o le attività quotidiane sono limitate dalla sua spalla?
No = 4, Moderata limitazione = 2, Intensa limitazione = 0 ___
2. Il suo tempo libero o le attività ricreative sono limitate dalla sua spalla?
No = 4, Moderata limitazione = 2, Intensa limitazione = 0 ___
3. Il suo sonno è disturbato dalla sua spalla?
No = 2, Qualchevolta = 1, Si = 0 ___
4. A quale livello può usare il braccio affinchè il movimento sia ragionevolmente indolore?
Vita = 2, Xifoide (sterno) = 4, Collo = 6, Testa = 8, Sopra la testa = 10 ___

C.- Range di movimento (parte riservata al dottore o al fisioterapista) (/40): Totale (1 + 2 + 3 + 4) ☐

1.- FWD Flessione: 0 - 30 0 pts
31 -60 2 pts
61 - 90 4 pts
91 - 120 6 pts
121- 150 8 pts
> 150 10 pts
Gradi ___ ☐

2.- Abduzione: 0 - 30
31 - 60
61 - 90
91 - 120
121 - 150
> 150
___ Gradi ☐

3.- Rotazione Esterna: ___
Mano dietro la testa e gomito avanti 2
Mano dietro la testa e gomito dietro 4
Mano sopra la testa e gomito avanti 6
Mano sopra la testa e gomito dietro 8
Completa elevazione del braccio 10
Gradi ☐

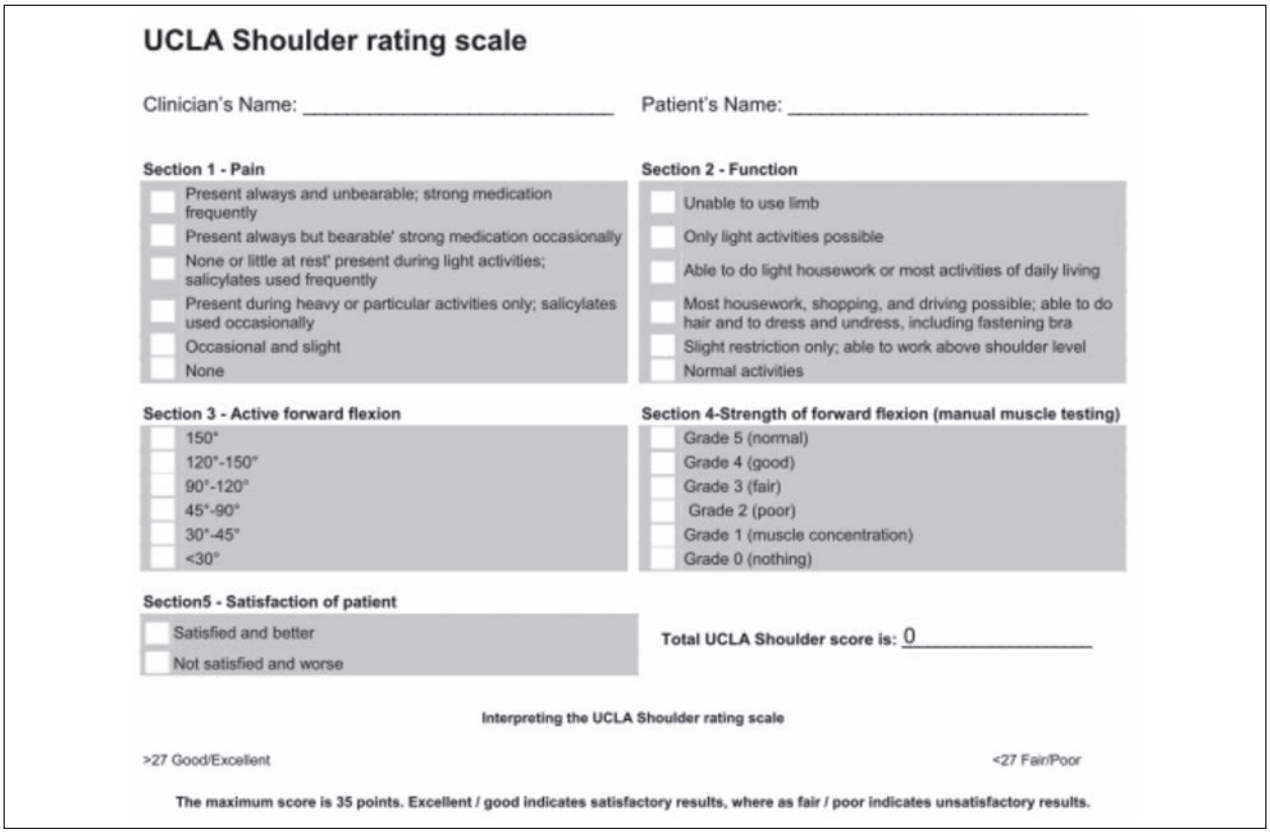
4.- Rotazione Interna: (Dorsum hand to) ___
Coscia 0
Natica 2
Articolazione SI 4
Vita 6
T12 8
Tra le scapole 10

D.- Forza (/25): Punti: media (kg) x 2 = ☐ D
Prima pull: Seconda pull: Terza pull: Quarta pull: Quinta pull:
Media pulls:

TOTALE (/100): A + B + C+ D ☐

Stima soggettiva post-operatoria del paziente:
1=Molto migliorata; 2=Migliorata; 3=Invariata; 4=Peggiorata ☐

**Figure 3.** The Constant Shoulder Score. From www.otodi.it/aploto/allegato/107/costant-score.do



**UCLA Shoulder rating scale**

Clinician's Name: _____ Patient's Name: _____

**Section 1 - Pain**

- Present always and unbearable; strong medication frequently
- Present always but bearable' strong medication occasionally
- None or little at rest' present during light activities; salicylates used frequently
- Present during heavy or particular activities only; salicylates used occasionally
- Occasional and slight
- None

**Section 2 - Function**

- Unable to use limb
- Only light activities possible
- Able to do light housework or most activities of daily living
- Most housework, shopping, and driving possible; able to do hair and to dress and undress, including fastening bra
- Slight restriction only; able to work above shoulder level
- Normal activities

**Section 3 - Active forward flexion**

- 150°
- 120°-150°
- 90°-120°
- 45°-90°
- 30°-45°
- <30°

**Section 4-Strength of forward flexion (manual muscle testing)**

- Grade 5 (normal)
- Grade 4 (good)
- Grade 3 (fair)
- Grade 2 (poor)
- Grade 1 (muscle concentration)
- Grade 0 (nothing)

**Section5 - Satisfaction of patient**

- Satisfied and better
- Not satisfied and worse

**Total UCLA Shoulder score is:** 0

**Interpreting the UCLA Shoulder rating scale**

>27 Good/Excellent <27 Fair/Poor

**The maximum score is 35 points. Excellent / good indicates satisfactory results, where as fair / poor indicates unsatisfactory results.**

**Figure 4.** The UCLA shoulder rating scale. From www.orthopaedicscores.com

der score (22) (Fig. 4). Moreover, we have also detected patient's satisfaction by questions (excellent, good, mild or poor satisfaction) at final follow-up and over the final follow-up. This investigation for satisfaction's degree was carried out by recall rating when we started this retrospective analysis (mean 26 months, range: 18-65 months after surgery). Radiographic follow-up was done by use of standard anteroposterior and axillary lateral radiographs, such as notching and loosening was performed independently by two trained raters. A statistical analyses were performed achieving the comparison between postoperative clinical scores and the degrees of satisfaction was carried out using the Wilcoxon-Mann-Whitney test. P values lower than 0.05 were considered statistically significant.

## Results

Of 33 patients treated, 2 patients died for reasons not related to the shoulder arthroplasty before our retrospective analysis started. Final follow-up was 12 months for all patients. The mean age at the surgical time was 75.7 years (range, 55-88 years). In 24 cases the dominant limb has been replacement. Previously one patient underwent to an arthroscopic repair of the supraspinatus tendon in the same shoulder.

At the time of follow-up all thirty-three patients showed a marked improvement in elevation, abduction and intrarotation, except in extrarotation. The maximum grade of ROM was obtained at 1 year after replacement. The mean active anterior elevation was 150°(range 140°-170°) and mean abduction was 140° (range 120°-160°) Only the mean active extrarotation (25°, range 10°-30°) and passive extrarotation (35°, range 20°-45°) didn't had a objective improvement. Unlike some other series, our patients were able to internally rotate further than the hand reaching the ipsilateral buttock (Fig. 5). In our series, active internal rotation of patients ranging from L1 to L5 after 12 months.

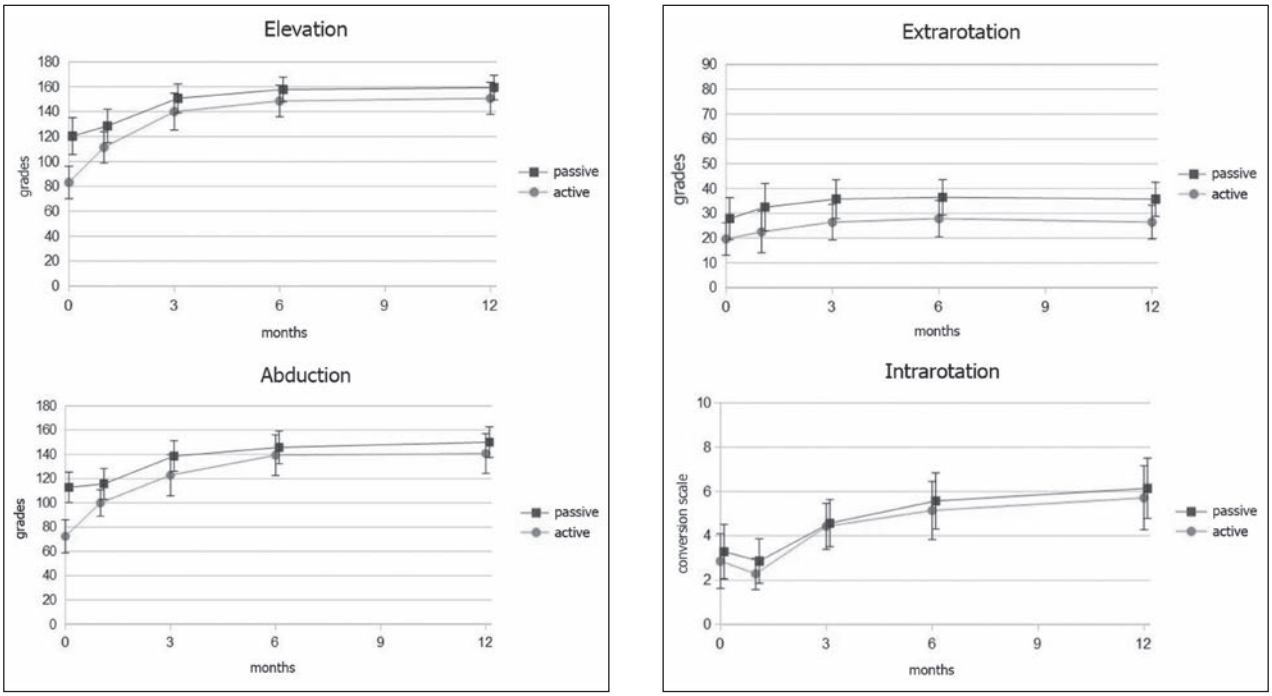



**Figure 5.** Postoperative improvement in active and passive ROM: abduction, elevation, extrarotation and intrarotation. Internal rotation was reported as the vertebra that the patient can reach with the hand keeping the elbow flexed to 90°. We assigned 10 points for internal rotation up to the spine of the scapula; 8 points for internal rotation ranging from L1-L3 ; 4 points for internal rotation ranging from L4-sacrum; 2 points for internal rotation at gluteus; 0 points for internal rotation at thigh

Constant Shoulder Score was submitted to the patients before surgery and at the latest follow-up (Table 1). The difference between mean pre-operative and post-operative values was interesting: the mean Constant score improved by 35,7 points. Furthermore also the UCLA score after 12 months was satisfying (29, 85 of 35 points).

At the final follow-up all patients had no or minimal pain as measured with a visual analog score.

VAS decreased from a pre-operative mean value of 3.8 (range: 3 - 5) to a mean value of 0.1 (range: 0 - 2) after 12 months (Fig. 6).

Overall, 90.3% (28 patients) rated their outcome as good or excellent. 27 patients (87.1%) reported pain-free ROM, function and strength of the replaced shoulder. Instead, one patient, at the time of analysis, declared that he was not satisfied for a distal humerus fracture with a complete lesion of radial nerve occurred 1 year after shoulder replacement.

Three patients (9.6%) unveiled the persistence of mild pain but they were satisfied for the functional healing. Two patients of these (6,4%) reported poor satisfaction because they did not notice any subjective improvements.

**Table 1.** Change in Constant score medium values before the surgery and after 1 year; UCLA score after 1 year

| Test | Pre-operative | Post-operative (1 aa) |
|---|---|---|
| Constant | 44,3 | 79,9 |
| UCLA | // | 29,85 |

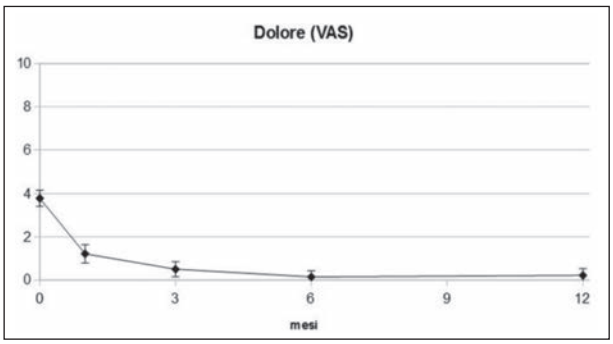



**Figure 6.** Mean pain relief in 12 months

Patients were then shared into two groups according to the satisfaction degree and we have evaluated the differences in functional outcomes. The variation of Constant Shoulder Score and the UCLA score showed a significant difference between the two groups (Table 2).

No patients developed specific complications (dislocation, infection, bleedings, nerve palsy, acromial fractures glenoid loosening, pulmonary embolus).

No case of glenoid or humeral component loosening were seen in our series at this early radiographic follow-up. The first signs of impingement were seen 6 months after shoulder replacement and inferior scapular notching was detected in 8 patients (24%) in our series. This patients developed a low grade of scapular notching (<5mm) which did not reach the lower screw (23, 24) (Fig. 7).

The Nerot-Sirveaux grading system (25) (Fig. 8) for inferior notching could not be applied because the variable angle of the inferior screw in this implant type and different resolution and views of radiographies. Radiographic follow-up was performed in different radiology departments. Moreover, the presence of notching did not present any relationship with the functional outcomes.

**Table 2.** UCLA shoulder rating scale and variation of Costant shoulder score according to the satisfaction degree

| | Satisfied | Not satisfied | p-value |
|---|---|---|---|
| UCLA | 30.8 | 18.0 | 0.010 |
| Δ Costant score | 37.4 | 4.5 | 0.038 |

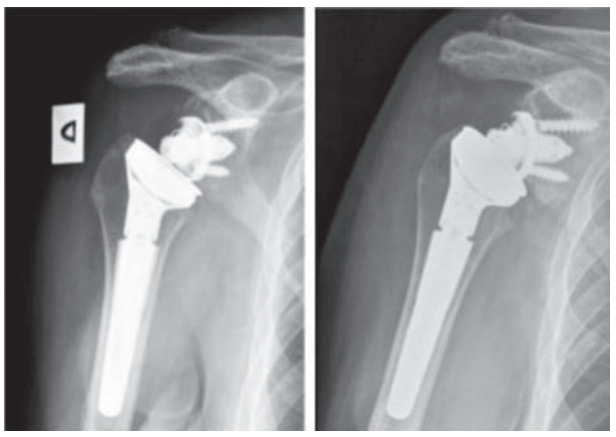


**Figure 7.** Scapular notching after 6 months from shoulder replacement

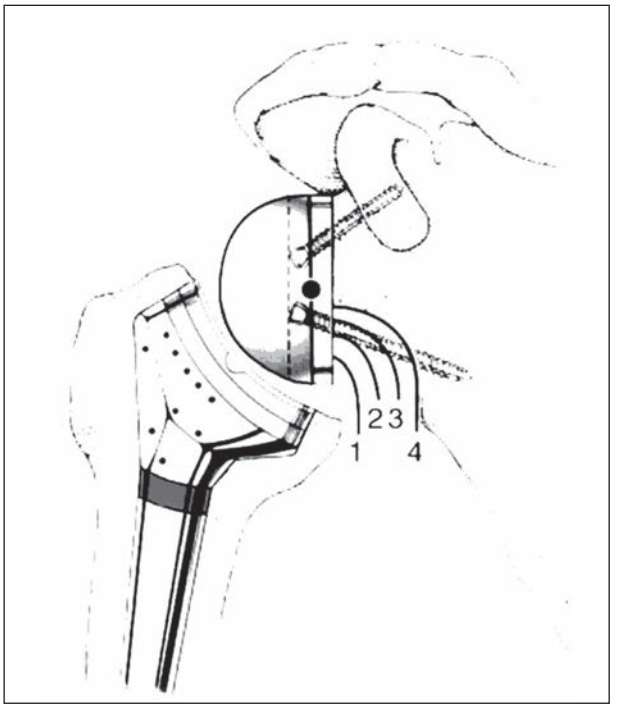



**Figure 8.** Scapular notching classification according to the Nerot-Sirveaux grading system.
Foto modificata from http://shoulderarthritis.blogspot.it/2014/01/scapular-notching-in-reverse-shoulder.html

## Conclusions

Outcomes of RSA for the management of MIRCT and CTA showed the capacity to restore pain-free ROM, function and strength, improving the quality of life. All functional scores increased significantly after surgery. In addition, patients in our series was able in active internal rotation ROM after RSA, although some studies have shown the inability to internally rotate (24, 26).

A better internal rotation ROM can be achieved improving the humeral stem antiversion (15, 16, 27).

Moreover, when the retroversion of the humeral head was 0°, patients showed better results in in internal rotation activities (28, 29).

Active external rotation was lower than the other ROM considered. The loss of the external rotation is a

serious problem disclosed by several authors (30, 31), specially for patients using the arm in abduction. Also elevation recovery may not be enough to bring up this deficit. In literature no statistically significant differences were found in functional results of patients underwent RSA with the humeral stem placed at 30° of retroversion with those underwent RSA with humeral stem placed at 10°-20° of retroversion, while external rotation ROM was better in patients with the humeral stem placed at 30° of retroversion (32).

The external rotation ROM depends by the teres minor muscle conditions because both in MIRCT and CTA disorders the postero-superior aspect of the RC is deficient. Particularly in older patients, teres minor (TM) muscle is often retracted, atrophied or fatty infiltrated (33). Some authors suggest preoperative MRI assessment of the TM to predict its ability to externally rotate the arm and to plan also a tendon transfer procedure or humeral retroversion improvement (30, 34).

In this paper patients expressed good or excellent satisfaction (90.3%) after shoulder arthroplasty reported in other studies 11. The majority of patients gradually regained daily activities, homework and gardening activities and someone returned to perform light sports like swimming and golf. A patient returned to work hard in farmhouse. Other series showed the patients return to participate in sports after RSA Between 75% and 85% of the cases (35, 36).

Scapular notching is a specific complication of RSA reported by several studies. It is defined as resorption of the lateral pillar of the scapula. The incidence is between 49% and 70% of patients but it increase with time (23, 25, 37, 38). 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 (39).

Nevertheless it is unknowing if it affect the function or lead to replacement loosening (8). Despite his doubtful clinical effect, It is much better to avoid this complication. To easily reduce incidence of notching, the glenosphere should be positioned as low as possible on the glenoid. An overhang of just 1 mm reduce the incidence of notching (40). But this foresight can induce acromial fracture for deltoid lengthening (41).

In our study 8 patients (24%) showed a low grade (grade 1 of the Nerot-Sirveaux classification) of scapular notching after 6 months from surgery according to results of Boileau and Sirveaux, without signs of progression of notches to glenoid loosening at 12 months postoperatively (8, 25, 42).

The development of glenospheres with eccentric and larger diameters (44mm) has contributed to minimizing the incidence of scapular notching, improving ROM by increasing adduction and abduction.

The improved adduction may reduce mechanical impingement and hence the risk of scapular notching (43, 44).

In our experience, the use of a glenosphere 44 mm compared to that of 36 mm has apparently reduced the impingement, by its eccentric design and larger diameter. All patients who underwent to shoulder replacement with large glenosphere showed no evidence of lysis at 1 year after surgery.

The complication rate is higher than that of conventional total shoulder arthroplasty. Complications include those common to other shoulder procedures: infection (between 0%-4% in RSA), dislocation (between 2%-2.8% in RSA) and nerve palsy (between 0%-1.4% in RSA); and those unique to reverse total shoulder arthroplasty: scapular notching (between 49%-70% ); glenoid loosening (between 0%-4% ) and acromial fractures (between 1.4%-4%) (8, 37, 38, 45). Luckily, our case series was released from complications. The major limitation of our analysis is represented by the short follow-up in the context of arthroplasty surgery and by the outcomes regarding the length of the functional results of SMR RSA. An another important limitation is represented by the small population evaluated in the present study. In addition, all patients in this series were operated by the same arthroplasty shoulder surgeon, leading to the selection of bias and less different results. Finally, current designs of reverse shoulder arthroplasty is promising to treat CTA. Although in literature intraoperative and perioperative complications occur in a high percentage of patients and long term outcomes are difficult to predict for different designs, our early experience with SMR RSA in treatment of CTA shows a safe and effective surgical option to resolve pain and restore the capacity to perform daily activities.

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