# REVERSE SHOULDER PROSTHESIS IN TRAUMATHOLOGY. PRINCIPLES AND RESULTS

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***Abstract:*** *The reverse shoulder arthroplasty converts the glenoid into a spherical head and the head of the humerus into a socket, thus providing a stable fulcrum for glenohumeral joints with deficiency of the rotator cuff. The reverse prosthesis has become a treatment of choice for glenohumeral osteoarthritis in a cuff deficient shoulder. It allows restoration of mobility despite the loss of rotator cuff function. Hemiarthroplasty fails most commonly because of tuberosity nonunion in about 40 %. Therefore, in the face of poor bone quality, the reverse prosthesis is a logical choice for acute fractures to improve postoperative mobility in elevation regardless of tuberosity healing. Nevertheless, the healing of the tuberosities may influence the recovery in active external rotation. The purpose of this article is to report on the superolateral technique to implant a reverse shoulder prosthesis for acute proximal humeral fractures, emphasizing the technique of tuberosity fixation, and to analyze previously published series. Considering the follow-up and complication risks, the reverse prosthesis should be reserved for fractures involving elderly patients over 70 years old.*

***Cuvinte cheie:*** *proteza inversată de umăr, fractura humerus proximal, tehnica operatorie, fixare metafizară*

***Rezumat:*** *Proteza inversată de umăr (PIU) a devenit o opțiune terapeutică importantă în artropatiile glenohumerale cu leziuni majore ale coafei rotatorilor, ireparabile. Această proteză permite restaurarea mobilității în pofida unei deficiențe a coafei rotatorilor, spre deosebire de proteza anatomică, la care, pentru a funcționa, este nevoie de o coafă indemnă sau reparată. Hemiartroplastia, considerată standardul în fracturile de extremitate proximală de humerus ce necesită protezare, este marcată de o rată a eşecului funcțional de cauză nonseptică, în aproximativ 40% din cazuri, eşec pus pe seama deficitului coafei rotatorilor, în principal prin neconsolidarea fragmentelor metafizare fixate în jurul protezei. Chiar şi în cazul consolidării acestora, o limitare a rotației externe este întâlnită într-un procent foarte mare dintre pacienții operați. Scopul acestui articol este de a descrie tehnica artroplastiei cu proteza inversată de umăr în fracturile de extremitate proximală de humerus prin abord supero-extern şi de a analiza rezultatele seriilor publicate pe această temă. Riscurile operatorii importante şi dificultățile în urmărirea postoperatorie a pacienților care beneficiază de o astfel de intervenție sunt date de faptul că această operație este rezervată pacienților vârstnici, peste 70 de ani.*

The reverse shoulder arthroplasty is a concept introduced in the '80th as a solution to degeneratif shoulder with major cuff deficiency. For these patients an anatomical shulder prosthesis was marked by bad functional out comes. The promoter of this prosthesis, Paul Grammont, made an extension of the indications of it to the patients with humeral proximal fracture associated with rotator cuff insufficiency (a study for 22 patients between 1989 and 1993) but the outcomes were not published.

The design of this prosthesis is based on changing the contact face between humerus end glenoidian cavity, by transforming this face from convexe to extern in concave, making at the same time a medialisation and down migration of the gleno-humeral centre of rotation (Grammont concept).

This *new position* allow an augmentation of the force in deltoid muscle in abduction. This new situation compensate the rotator cuff deficiency.

The Grammont's concept was modified by Bigliani and Boileau for the reason to reduce the complications of this new position like osteolysis and noching of the inferior part of the glenoid.

Boileau had modified this concept by lateralized rotation center using a modified metaglen or a bon cancelos graft, keeping the low position of the humerus, without diminution of the function.

For Bigliani, a correction of just 5° in the angle of humeral stem is enough for reducing the noching phenomena.
The results of the reverse prosthesis for cuff tear arthropathy and after resection for tumor demonstrate that the reverse design restores active mobility in elevation despite a functionally incompetent rotator cuff.(1,2)

Published results on hemiarthroplasty for fractures clearly demonstrate the poor results from the loss of rotator cuff function because of tuberosity migration or nonunion. Moreover, in cases of revision for a failed hemiarthroplasty, the reverse prosthesis improves shoulder function.(3,6) The use of the reverse prosthesis for proximal humeral fracture appears logical in select elderly patients. Only a few small series have

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reported the results of the reverse prosthesis for fracture, and the level of evidence is still low.(7-9)

**Indications and contraindications**

The current **indications** for shoulder prosthesis in the setting of acute fractures include a displaced 4-part fracture with or without humeral head dislocation, a head splitting or impaction fracture involving more than 40% of the articular surface, and some 3-part fractures with marked displacement and diminished bone stock. The reverse prosthesis may be used in elderly patients when they present with poor prognostic factors for successful hemiarthroplasty: age older than 70 years, medical comorbidities, poor bone quality of the tuberosities, and preoperative fatty infiltration of the rotator cuff or the inability to complete postoperative immobilization and rehabilitation protocols.

The reverse prosthesis is **contraindicated** in young active patients (except as a salvage procedure), in cases of active infection or axillary nerve injury, and in patients with insufficient bone stock for secure fixation of the baseplate. Considering the risk of hematoma after reverse shoulder implantation regardless of the diagnosis, it is preferable to delay the procedure for 2 to 6 days after the trauma to decrease perioperative bleeding.

**Preoperative assessment**

Thorough patient evaluation with history and physical examination is mandatory. Considering the age of these patients, it is important to assess their overall health status and address or eliminate medical comorbidities that can preclude the safe administration of anesthesia. Evaluation of the contralateral shoulder should be completed considering the current limitation in internal rotation with the reverse prosthesis. In every case, it is critical to evaluate the axillary nerve for injury. The deltoid must be evaluated by clinical examination and, if any questions arise, with an electromyogram. The muscle should be functional and contractile at the clinical examination. Weakness of the deltoid does not represent a strict contraindication to a reverse prosthesis. Radiographic studies needed to assess and classify the fracture include standard x-rays and a computed tomographic (CT) scan. The CT scan provides a clear illustration of the position of the humeral head and tuberositiesin complex situations (10,11) and allows evaluation of the rotator cuff tendons and fatty infiltration of the cuff musculature. The CT scan demonstrates glenoid bone defects and allows preoperative planning for the position of the central peg of the baseplate. Bilateral full-length x-rays are useful to evaluate the amount of proximal bone loss in cases of comminuted fractures involving the metaphysis and allow the surgeon to template the approximate height of the prosthesis for insertion.

**Figure no. 1. Reverse shoulder prosthesis**

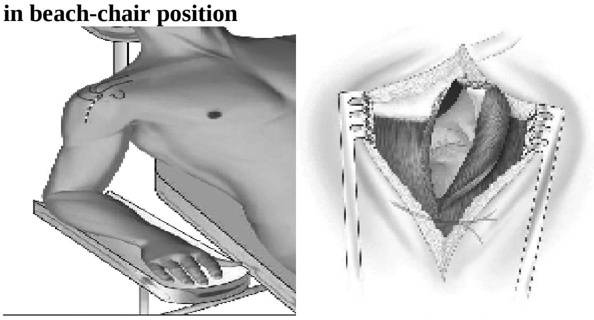
**Surgical technique**

**Approach**

The preferred method and recommendation is to use the superolateral approach for these cases; however, the deltopectoral approach may be used as well. It has been demonstrated that the risk of instability is higher by using the deltopectoral approach.(15) In fractures cases, there is a potential risk of instability because of hematoma, detachment of the lesser tuberosity, and proximal bone loss; in these cases, the superior approach seems preferable. The deltopectoral approach is useful when the fracture extends distally down the humeral shaft and an extensile approach is required.

The patient is placed in a beach-chair position. A longitudinal incision is made, starting from the acromioclavicular joint and running distally for 4 cm from the lateral edge of the acromion (figure no. 2)

**Figure no. 2. Longitudinal approach with the patient placed in beach-chair position**

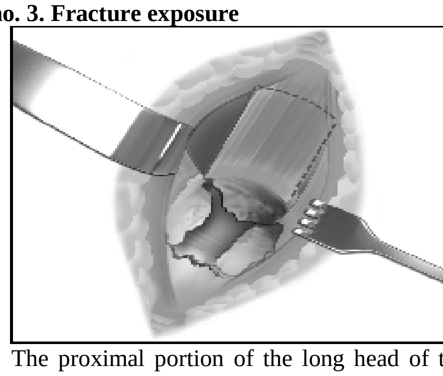


The anterior and middle deltoid muscles are separated, a retractor is placed in the subacromial space, and the fracture hematoma is removed. A stay-suture can be applied to the distal deltoid split to avoid potential damage to the axillary nerve. A deltoid split can be extended distally but requires direct visualization and vigilance during the procedure to isolate and protect the axillary nerve.16 The anterior deltoid and the coracoacromial ligament are detached subperiosteally from the acromion. An anterior acromioplasty may be performed if necessary to improve exposure. The deltoid is retracted anteriorly, and the subacromial bursa is removed.

**Fracture Exposure**

The first step is to identify the fracture fragments. The rotator interval is opened along the bicipital groove between the subscapularis and the supraspinatus. The interval between the supraspinatus and the infraspinatus is also identified and opened. The supraspinatus tendon is then resected to the level of the glenoid rim (figure no. 3).

**Figure no. 3. Fracture exposure**



The proximal portion of the long head of the biceps tendon is resected and the humeral head fragment removed. The greater tuberosity is mobilized posteriorly, and 4 mattress sutures are placed two through the infraspinatus tendon and two through the teres minorVat the tendon-bone junction (Fig. 3).

The lesser tuberosity is identified anteriorly, and 2 stay-sutures are placed through the subscapularis tendon at the tendon-bone junction. The lesser tuberosity is retracted anteriorly for glenoid exposure.

**Figure no. 4. Posterior placement of the lesser tuberosity with 2 stay-sutures**

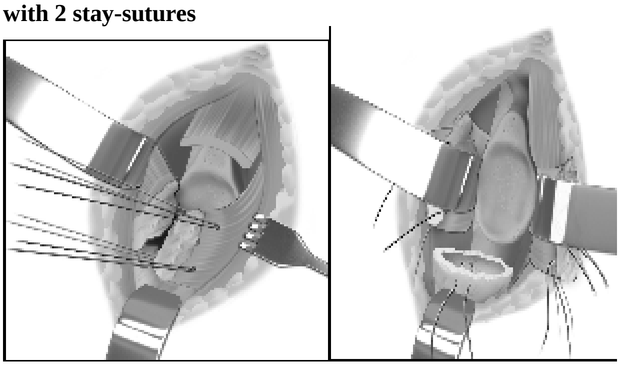
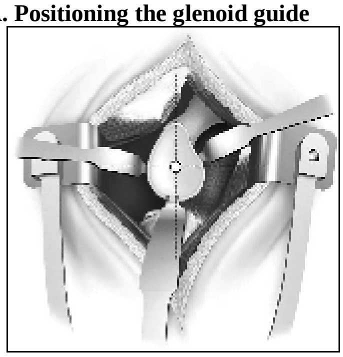


**Figure no. 5A. Positioning the glenoid guide**



**Glenoid Preparation**

The glenoid is prepared first, and the baseplate inserted without cement as customary.

The lesser tuberosity is retracted anteriorly and the greater tuberosity posteriorly by using 2 Homan retractors. Because of the epiphyseal fracture, gentle caudal traction is usually sufficient to expose the inferior portion of the glenoid (figure no. 5).

**Figure no. 5B. Posioning the glenoid guide**

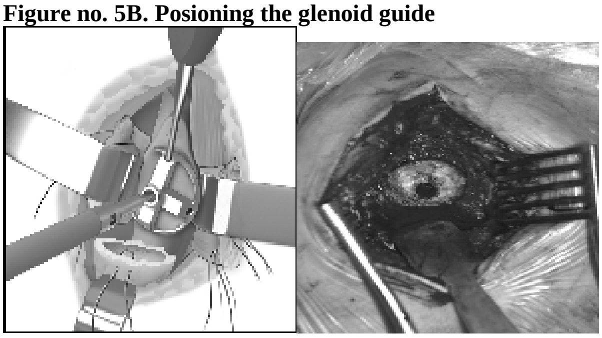
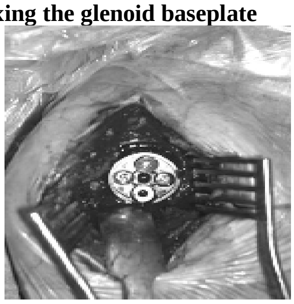


**Figure no. 6. Fixing the glenoid baseplate**

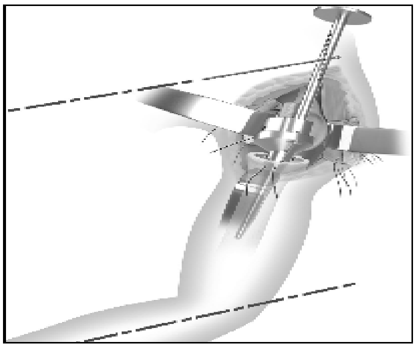


The meridian and equator of the glenoid are marked with an electrocautery to establish a reference for guide placement and reaming. We align the 6-mm drill guide with the inferior border of the glenoid with a 10-degree inferior tilt to allow for inferior placement of the glenosphere (figure no. 6). The baseplate is fixed as described by Hatzidakis,19 and the sphere is impacted and secured with the central screw into the peg of the baseplate.

**Humeral Stem Preparation and Trialing**

The proximal humerus is dislocated laterallyand superiorly with the greater tuberosity retracted posteriorly and the lesser tuberosity retracted anteriorly. Distal diaphyseal reaming is performed. The metaphyseal reamer is usually unnecessary in these cases secondary to metaphyseal comminution but should be used if metaphyseal bone is present. The trial component is assembled and inserted into the diaphysis at the preoperatively determined height in 20 degrees of retroversion and impacted with a mallet as necessary (figure no. 7).

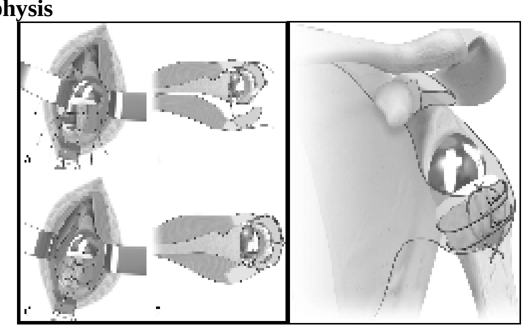
**Figure no. 7. Trial component assembly and insertion into the diaphysis**



The preoperatively determined height of insertion is a useful guide in cases of proximal bone loss but is not definite. The prosthesis is reduced and its final height adjusted according to the tension of the deltoid. Minimal diastasis should be present between the cup and glenosphere with axial stress. The prosthesis must be stable secondary to deltoid tension alone before fixation of the tuberosities.(19) The height may be adapted, after cementation, with the trial humeral inserts (6, 9, or 12 mm) or by adding a metaphyseal extension (+9 mm). In cases of diaphyseal involvement, a long-stem prosthesis is required.

**Final Implantation and Tuberosity Reattachment**

**Figure no. 8. Sutures for positioning the tuberosity and diaphysis**



The trial component is dislocated and removed. Two holes are drilled laterally in the proximal humeral diaphysis 2 cm distal to the fracture. Two nonabsorbable sutures are passed through the holes to create a suture loop in the diaphysis. Then, the final hybrid humeral component (uncemented hydroxyapatite covered metaphysic and cemented stem) is assembled. A cement restrictor is inserted to the appropriate depth, and the medullary canal is dried. After injecting the cement, the prosthesis is inserted into the canal, through the suture loop, in 20 degrees of retroversion. The sutures are now secured around the prosthesis, which will improve tuberosity fixation in elderly patients. Excess cement is removed proximally at the metaphyseal junction. After the humeral component is well fixed and the cement is dry, a final trial reduction should be performed with the inserts to confirm stability and appropriate deltoid tension. The final polyethylene component is inserted, and the prosthesis is reduced. The sutures passing through the infraspinatus and teres minor should be passed around the neck of the prosthesis before reduction. After reduction, the tuberosities are mobilized and reduced temporarily around the metaphysis. The technique of tuberosity fixation is derived from the 6-suture configuration technique described by Boileau in 2000 for hemiarthroplasty in acute fracture. The greater tuberosity is first fixed by tying 2 of the previously passed sutures around the neck of the prosthesis (figure no. 8). The remaining 2 sutures are passed around the neck of the prosthesis, through the tendon bone junction of the subscapularis, and tied in the horizontal plane. The transosseous metaphyseal sutures are used as a figure-of-8 to improve the fixation between both tuberosities and the diaphysis.

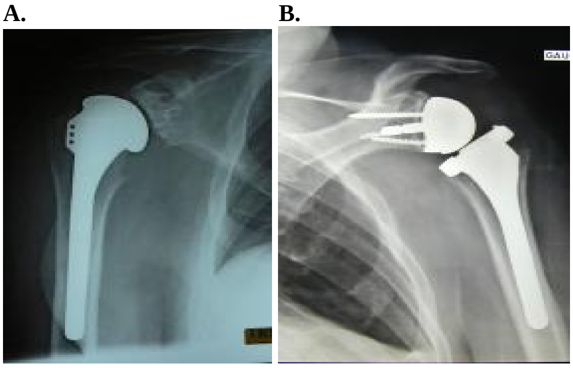
Due to medialization of the proximal humerus, there is no tension on the rotator cuff. After tuberosity fixation, the range of motion, stability, and soft tissue tension are evaluated to design the postoperative program. A meticulous antiseptic irrigation of the subacromial space must be performed to remove the hematoma and bone particles to prevent infection and ossifications. Considering the high risk of hematoma, the use of a suction drain in the subacromial space for a minimum of 2 days, is indicated. At the end of the procedure, the anterior deltoid must be securely reattached using transosseous nonabsorbable sutures to the acromion. These sutures should grasp both the superficial and the deep deltoid fascia.(17)

**Rehabilitation**

There are no scientific data to support one method of rehabilitation over another. Some authors recommend immobilization for 4 weeks in slight abduction and neutral rotation (17,19) with early passive motion, whereas others advocate using only a simple sling. We recommend an environment conducive to tuberosity healing and to prevent tuberosity migration.

**Figure no. 9 A. Hemiarthroplasty B. Reversed prosthesis**

**A.** **B.**



The results of a prospective study showed that the patients treated with a reverse prosthesis in the case of acute fracture achieved an average of 113 degrees of active elevation compared with 88 degrees with hemiarthroplasty.(18) The overall results were not as good as in patients treated with a reverse prosthesis for cuff tear arthropathy. The problem of tuberosity healing and cuff dysfunction is only one of the reasons for failure of the prosthesis for fracture.

In 2006, Cazeneuve and Cristofari (8) reported their experience of 23 cases of reverse prostheses for acute fracture. Sixteen cases were reviewed at an average follow- up of 86 months. The mean age of the patients was 75 years (range, 58 to 90 years). The prosthesis was cemented in all cases but one, and the tuberosities were sutured in 5 cases. Four complications were reported: 1 dislocation and 1 infection (both revised), and 2 cases of reflex sympathetic dystrophy. The mean constant score was 60 points, and active anterior elevation was more than 120 degrees in all the cases except for the 2 cases requiring revision. The recovery of active external rotation was better in cases where the tuberosities had been fixed. On x-rays, a scapular notch was noted in 69% of the cases, and 1 metaglene had become loose.

Bufquin et al. reported the largest series of reverse prostheses for fracture (43 casesV40 included with a mean age of 78 years). Eleven percent of the patients had associated traumatic fractures. The superolateral approach was used in 20 cases and the deltopectoral approach in 23 cases. The tuberosities were fixed around the prosthesis in all the cases. The humeral component was uncemented in 37 cases. A proximal epiphyseal augment was required to improve the stability of the prosthesis in 15 cases. The authors recommended implanting the humeral component in neutral rotation, but they did not demonstrate any statistical influence of component rotation on the clinical results. A 28% (12 cases) rate of complications was reported in this study. There was 1 perioperative glenoid fracture, 5 transient neurological deficits, 1 acromion fracture, 1 dislocation, 1 secondary deltoid rupture, and 3 cases of reflex sympathetic dystrophy. At a mean follow-up of 22 months (range, 6Y58 months), the average active anterior elevation was 97 degrees. The Constant score averaged 44 points, and the mean active external rotation in abduction was 30 degrees. The clinical results were lower for patients older than 75 years, and the recovery in active external rotation was better when the greater tuberosity had healed anatomically. Radiographically, the tuberosities were displaced in 53% of the cases (13.8% malunion and 38.8% nonunion), and 90% showed periprosthetic ossifications.

Recently, a small series of 15 cases, retrospectively reviewed with more than 2 years' follow-up, from a large multicenter study of reverse prostheses, has been reported (9) (mean age, 78 years). At a mean follow-up of 46 months, the mean constant score was 55 points (range, 31Y73 points), the mean active anterior elevation was 107 degrees, and the mean external rotation was 10 degrees. The recovery of active external rotation was possible when the greater tuberosity healed, but this was not supported by the statistical data because of the small number of cases. These results have been compared with a series of elderly patients treated with hemiarthroplasty. The mean results in active anterior elevation were not significantly different between the 2 groups, but the distribution of the results was different. In the reverse group, only 1 patient had less than 90 degrees of active anterior elevation, but the active anterior elevation never exceeded 150 degrees, whereas in the hemiarthroplasty group, 11% had more than 150 degrees, but 50% achieved only 90 degrees or less. In the hemiarthroplasty group, the constant score was strongly influenced by tuberosity healing. The mean constant score was 41.9 points in cases of nonunion or malunion of the greater tuberosity compared with 59 points when the greater tuberosity healed (P *G* 0.01). The same results were observed for active anterior elevation and active external rotation (75 vs 116 degrees, and 25 vs 14 degrees, respectively). If we considered active elevation in both groups with nonunion or malunion of the greater tuberosity, the results would be in favor of the reverse prosthesis. When the greater tuberosity did not heal, the mean Constant score was 55 points for the reverse prosthesis and 41 points for the hemiarthroplasty (P = 0.12). The mean active anterior elevation was 75 degrees in the hemiarthroplasty group and 116 degrees in the reverse group (P = 0.01). The active external rotation was not statistically different, 16 degrees in the hemiarthroplasty group and 13 degrees in the reverse group. This study demonstrates that good results and near-normal range of motion can be achieved in elderly patients treated with hemiarthroplasty for acute fractures. However, if good fixation and healing of the tuberosities are not achieved, poor functional outcomes can be expected. The reverse prosthesis provides improved clinical results in these cases. The reverse shoulder prosthesis must be considered as an alternative to hemiarthroplasty in select elderly patients. Indeed, shoulder hemiarthroplasty performed for acute fracture is more demanding than one performed for other indications (12) and hemiarthroplasty performed by a high-volume surgeon or high-volume hospital is more likely to result in a better outcome.(21,22)

The reverse prosthesis is somewhat more forgiving because the recovery in elevation can be expected despite tuberosity nonunion or malunion as demonstrated by this study. However, the healing of the greater tuberosity is still necessary to recover active external rotation. The results of the reverse prosthesis are clearly influenced by technical factors, and the surgeon must consider the high risk of complications which can compromise postoperative shoulder function and the ultimate level of independence of these patients. In addition, the reverse prosthesis is a constrained prosthesis, and the current literature raises concerns regarding the durability of the fixation of the prosthesis in the long term.(23) Indeed, Guery et al. (24) showed that the survival rate of the reverse is better in cuff tear arthropathy than other etiologies (rheumatoid arthritis, trauma, and revision). The indication for a reverse prosthesis in acute fractures should be based on realistic expectations of tuberosity nonunion around a hemiarthroplastyVwhich would result in a poor outcome with hemiarthroplasty. The decision to use a reverse prosthesis in an elderly patient with an acute fracture should be based on a thoughtful riskbenefit analysis between hemiarthroplasty and reverse shoulder arthroplasty.

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