Reverse Shoulder Arthroplasty – State of the Art

Francesco Franceschi 1,2*, Edoardo Giovannetti de Sanctis 1,2, Ashish Gupta 3, George S. Athwal 4, Giovanni Di Giacomo 5

1. UniCamillus-Saint Camillus International University of Health Sciences, Rome, Italy. francesco.franceschi@unicamillus.org; edoardo.giovannettids@gmail.com
2. Department of Orthopaedic and Trauma Surgery, San Pietro Fatebenefratelli Hospital, Rome, Italy.
3. Queensland Unit for Advanced Shoulder Research (QUASR), Queensland University of Technology, Brisbane, QLD 4000, Australia.
4. The Roth McFarlane Hand and Upper Limb Centre, St. Joseph’s Hospital, London, ON, Canada.
5. Concordia Hospital for Special Surgery, Rome, Italy. concordia@iol.it;

Correspondence: Francesco Franceschi MD. UniCamillus-Saint Camillus International University of Health Sciences, Rome, Italy. Department of Orthopaedic and Trauma Surgery, San Pietro Fatebenefratelli Hospital, Rome, Italy; francesco.franceschi@unicamillus.org;

+39/3358007236
Reverse Shoulder Arthroplasty – State of the Art

Abstract

The reverse shoulder arthroplasty conceived by Paul Grammont in 1985 has gradually gained popularity as a treatment for multiple shoulder diseases. Unlike previous reverse shoulder prostheses characterized by unsatisfactory results and a high glenoid implant failure rate, the Grammont design has immediately shown good clinical outcomes. This semiconstrained prosthesis solved the issues of the very first designs by medializing and distalizing the CoR with an increased stability of the replacement of the component.

The indication was initially limited to Cuff Tear Arthropathy (CTA). It has then been expanded to irreparable massive cuff tears and displaced humeral head fractures.

The most frequent problems of this design are a limited postoperative external rotation and scapular notching.

Different modifications to the original Grammont design have been proposed with the aim of decreasing the risk of failure and complications and improving the clinical outcomes.

Both the position and version/inclination of the glenosphere and the humeral configuration (e.g. Neck Shaft Angle) influence the RSA outcomes.

A lateralized glenoid (whether with bone or metal) and a 135° Inlay system configuration leads to a moment arm which is the closest to the native shoulder.

Clinical research will focus on implant designs reducing bone adaptations and revision rate, strategies to prevent more effectively infections.

Furthermore, there is still room for improvement in terms of better postoperative internal and external rotations and clinical outcomes after RSA implanted for humeral fracture and revision shoulder arthroplasty.
1.0 Introduction

Shoulder replacement was originally used as a salvage procedure in severely damaged joints.

The early history of shoulder arthroplasty has been widely reported.[26]

At the very beginning hemiarthroplasty was used. Although pain relief was obtained, the clinical outcomes reported by physicians were not satisfactory. This was frequently due by a superior migration of the humerus in patients without the stabilizing function of the rotator cuff (RC).

The anatomic total shoulder replacement then started to be used as a treatment for glenohumeral osteoarthritis (OA) and massive RC deficiency. The addition of a glenoid component was supposed to avoid the superior migration.

However, the outcomes were not satisfactory due to a high failure rate, mainly caused by an excessive edge loading with the rocking horse phenomenon. [58,26]

Patients with both OA and rotator cuff deficiency were defined by Neer as patients with “limited goals surgery”. [57]

The main challenge in shoulder replacement was recognized at that time to be increasing the joint stability in patients without a properly functioning RC.

To obviate the need for RC reconstruction different constrained designs were proposed: either with a design reversing the normal anatomy (socket in the proximal humerus and ball in the glenoid) or with higher constrained standard anatomic components.

As the dynamic stabilizers of the shoulder are not functioning properly, the prosthesis design is responsible for preventing the humerus from subluxating superiorly [6]. Reversing the position of the convex and concave surface has this goal.

The intrinsic stability of two prosthetic components depends on the ratio between their depth and diameter: the greater the socket depth the greater the stability of the prosthesis [36,11].

Also matching the radius of curvature between the convex and concave surfaces of the implant increases the stability.

The higher constrained standard anatomic component were abandoned due to an excessively high rate of glenoid loosening.
Several reverse implant designs were designed during the decades. The majority of those prostheses led to low clinical outcomes and a high failure rate due to glenoid component loosening, implant breakage and anterior instability, as one of the goals in these designs was to match the shoulder’s native joint center.

Paul Grammont in 1985 developed the first generation of a new system differing from the previous reverse shoulder designs [3,31,32]. Among the key features of this system: a medialized and distalized center of rotation (CoR); the glenoid component is uncemented; peripheral screws and a pressfit peg used for glenoid fixation; the humeral part is concave and the glenoid part is convex. Furthermore in the RSAs the CoR is shifted from the humeral head to the glenosphere and the humerus is distalized [10,6].

The movement of the shoulder produces a resultant force vector, composed of both compressive and shear forces varying throughout the range of motion that are assumed to cross the glenohumeral CoR [3].

The moment of force at the fixation interface is proportional to both the shear forces and the distance between the CoR and the implant-bone interface [41].

The medialization of the CoR makes the joint forces more compressive and decreases the moment of force at the glenoid-bone interface [15,6,50,41]

Lateralizing the CoR increases the distance from the bone implant interface resulting in a bigger moment of force [6].

The higher the compressive force, produced by the deltoid and remaining cuff tension, the greater the stability of the shoulder [35,14].

A quantitative measure of a joint stability is the stability ratio, defined as the maximum dislocating force the joint can resist related to a medial compression force. A normal glenohumeral joint has a stability ratio of approximately 0.5. A total shoulder arthroplasty has a ratio of approximately 1.0 [38,20]. An RSA has a stability ratio > 2.0. With the glenohumeral joint in 90% of abduction, the RSA is approximately 4 to 5 times more stable than a normal joint and 2 to 3 times more stable than a conventional total shoulder prosthesis [20]. The stability ratio increases approximately 60% with the glenohumeral joint at 90% of abduction and decreases with the arm in a fully adducted position [14].

The reverse total shoulder replacement relies on the deltoid muscle, instead of the rotator cuff to move the humerus.

The RSA design increases the deltoid lever arm as the CoR is medialized compared to the anatomic one. Furthermore more deltoid fibers are recruited for abduction, as are shifter laterally to the CoR [1].
The deltoid lever arm is also increased by the distalization of the humerus, as the overall tension produced by a muscle is the sum of active and resting tension [28].

2.0 Surgical technique

Under general anaesthesia, the patient is placed in a beach chair position with the arm in holder. A classical deltopectoral approach is generally preferred. The rotator cuff and biceps are assessed precisely. The long head of the biceps is systematically cut. The subscapularis is prepared with resorbable sutures. Different exposure techniques have been described to manage the subscapularis: tenotomy, peel and lesser tuberosity osteotomy. Capsulotomy and humeral head dislocation are then performed. The anatomical neck is identified. When needed a dedicated guide might be used to harvest a cylindrical or angled autograft from the humeral head. A resection of the humeral head is then performed according to the preoperative planning and frequently 2 mm below the articular cartilage. Each prosthesis has its own cutting guide depending on the design and the characteristics. The extent of retroversion is chosen by the physician. The medullary canal and metaphyseal zones are then prepared based on the stem designed used.

To expose the glenoid articular surface the labrum is excised completely. A circumferential periglenoid capsulotomy is carried out. The glenoid surface might be fully exposed. Several glenoid retractors have been developed (e.g. Hohmann, Fukuda). The cartilaginous surface might be removed with a curette. It is mandatory to identify the inferior margin for proper baseplate seating.

Different intraoperative instrument guidances (e.g. 10 degrees inferior tilt guide, PSI, Navigation) have been developed for glenoid reaming and baseplate positioning. A k-wire is frequently used as a guide for the glenoid reamer. The direction of the k-wire corresponds to the direction of the baseplate central peg. Reaming and baseplate positioning are based on the preoperative planning and should avoid excessive retroversion and superior inclination. Excessive reaming should be avoided to preserve the bone stock.

The baseplate is then impacted with or without the medially placed humeral bone autograft. It is then fixed with usually 2 to 4 screws, depending on the model implanted.

The goal is to place the screws as long as possible to increase the stability of the implant. The direction of the superior and inferior screws are respectively the coracoid and the scapular pillar. The other two screw might be place convergent or divergent to the central peg. The trial glenosphere is then placed.
The trial humeral components are positioned and the prosthesis is reduced. The muscular tension is then tested to evaluate if the metaphyseal tray and insert sizes are correct. The joint stability is then tested also by moving it in all directions and with slight traction along the body. It is also mandatory to evaluate there is no impingement especially in adduction and abduction. Once the components have been chosen, implant of the final components is performed beginning with the glenosphere. The subscapularis is repaired to its insertion. A drain is placed in the subacromial space. The incision is closed.

3.0 Rotator cuff repair in RSA
Debated is whether the RC should be repaired in RSAs [19]. The RSA at the beginning was indicated only for RC arthropathy and massive RC tears [66]. These indications have then been expanded including also glenohumeral arthritis with glenoid deficits classified as > A2 even without associated RC tears [17,30,61]. Theoretically repairing a RC tear should improve the glenohumeral stability decreasing the risk of dislocation and the ROM. This recommendation should be taken into account for medialized designs; whereas not repairing the subscapularis with a lateralized design has not shown to result in a greater risk of glenohumeral instability. This effect is due to the deltoid wrapping producing a more compressive joint load in lateralized designs [30]. Furthermore, It has been stated that repairing the subscapularis improves significantly internal rotation but some authors believe that this might decrease the postoperative external rotation and abduction [66,12]. In RSA the subscapularis is shifted inferiorly to the CoR, becoming an adductor for almost the entire range of motion [1].

4.0 RSA prosthesis design classification
A classification system has been proposed by Routman et al. to categorize the different RSA designs, based on the glenoid and humeral components characteristics. [59] Glenoid components might be classified as medialized or lateralized based on the CoR position. The position of the CoR is determined by the the glenosphere thickness and radius and the use of bone or metal augments. Humeral components are divided in medialized and lateralized based on the distance between the intramedullary canal axis and the CoR of the humeral liner. This distance is influenced by humeral NSA, the tray and insert thickness and osteotomy height.
The implants are therefore classified as: MedG-MedH (Medialized Glenosphere-Medialized Humerus), MedG-LatH (Medialized Glenosphere- Lateralized Humerus), LatG-MedH(Lateralized Glenosphere- Medialized Humerus), LatG-LatH (Lateralized Glenosphere-Lateralized Humerus). Each of these 4 configurations has pros and cons.

4.1 Medialized glenosphere

This configuration, which is part of the Grammont design, is characterized by a greater CoR medial shift. This theoretically would increase the abductor moment of the deltoid, requiring less force to elevate the arm and produce less shear forces at the baseplate-bone interface, improving glenoid fixation[64,1]. This configuration might lead to decreased external rotation due to a residual RC shortening, altered deltoid, therefore reducing the horizontal stabilizing compressive forces and an increased risk of scapular notching [39,40,64].

4.2 Lateralized Glenosphere

A glenosphere is defined as lateralized compared to the Grammont design. However, it is worth remember that this configuration CoR is still medialized compared to an anatomic shoulder.

Lateralization is achieved by using an eccentric glenosphere or using a bone or metal graft. This design improves deltoid wrapping which might decreases the risk of dislocation [64]. Furthermore, lateralizing the center of rotation has been suggested as a way of improving external rotation by retensioning the posterior rotator cuff (lengthening the origin-insertion distance) and recruiting more fibers of the deltoid for external rotation [6,8]. Conversely, with this configuration the deltoid has been show to be less efficient compared with a medialized glenosphere, with a decreased abductor moment. Therefore the deltoid must produce a greater force to elevate the arm, with negative implications on ROM and higher risk of stress fractures [64,66].

The Bony Increased Offset Reverse Shoulder Arthroplasty (BIO-RSA) has been proposed to address the problems of medialized design bringing the potential advantages of glenoid component lateralization without increasing the distance between the CoR and the implant-bone interface [8,22,24,9] (Figure 1).

Debated is whether a lateralized glenosphere is associated with a lower rate of scapular notching [64].
4.3 Medialized humerus

This configuration, which is part of the Grammont design, is characterized by an inlay metaphysis and a 155° NSA humeral stem. It shifts the humerus medially and distally to increase deltoid tensioning.

This configuration would: shorten the remaining RC affecting negatively postoperative internal and external rotation, increase the risk of scapular notching, increase the abduction passive ROM therefore reducing the risk of acromio-humeral impingement in abduction [11,6,40].

4.4 Lateralized humerus

A humerus might be lateralized reducing the NSA (from 155° to 135°), increasing the tray or insert thickness and using an onlay instead of an inlay metaphyseal component.

Lateralizing the humerus might increase the deltoid and remaining cuff tensioning, improve the deltoid wrapping and moment arm [40,10].

4.5 Effect of RSA design parameters on RC and deltoid muscles torques

Several problems have been associated to the Grammont design, mainly the scapular notching and a post-operative external rotation deficit [59,66].

Due to its non-anatomic design and to still unclear biomechanics, the ideal RSA configuration and the effects of on RC and deltoid moment arms is a debated topic.

As said previously, a force producing active motion through a joint is schematically composed of two components: one perpendicular to the lever arm (rotatory component) and one parallel to the lever arm (stabilizing component).

The force \( F \) is applied by the tendon at its insertion \( P \). The lever arm \( L \) is perpendicular distance between the line of action of the force and the CoR \( C \). The moment of force is a measure of its tendency to rotate a body about a specific point and depends on both the force, and on the lever arm (Figure 2).

Torque and moment arm are a measure of the effectiveness of a muscle to a specific motion.

The four RSA configurations and a native shoulder were compared in three planes of motion: scapular plane when considering abduction by action of the deltoid, axial plane when considering external rotation by the action of the deltoid and infraspinatus (Fig.2) and sagittal oblique plane when considering external rotation by action of the teres minor muscle.
Di Giacomo with his team performed an unpublished computational biomechanical analysis to assess moment arms and torque intensity of deltoid, infraspinatus and teres minor both in the native and in these 4 prosthetic reverse shoulder categories. It confirms that the RSA moves the CoR medially (2.25 cm in a MedG and 1.25 in. LatG) and leads to an increased moment arm in each pattern compared to an anatomic shoulder. (Figure 3)

Although the MedG/LatH configuration leads to the highest torque value for all examined muscles, the LatG/MedH configuration leads to a moment arm which is the closest to the native shoulder (Figure 4).

Although this study confirms the results of previous papers, the optimal amount of glenoid lateralization is still controversial.

5.0 Clinical Outcomes and Complications

The RSA has shown to be an effective treatment in decreasing pain leading to better shoulder function. The indications for this surgery are RC arthropathy, massive RC tears, glenohumeral osteoarthritis with a big glenoid bone defect and proximal humeral fractures.

Although during the last two decades the number of RSAs implanted per year has increased exponentially, the improvement in surgical technique, implant positioning and component designs has reduced the rate of complications and therefore revisions [27,69].

In the literature the complication rate varies from 0 to 75 %, with an overall value of 9.4 % [27]. Revision rate at 2 years has been shown to be 2.6 % [27].

At two years RSA has demonstrated to increase ASES (from 36.7 to 67.6) and Constant (from 32.2 to 69.0) score, decreasing shoulder pain. Active anterior flexion, abduction and ER improved respectively 56°, 50° and 14° [27]. The RSA has been shown to lead to an improvement in patient function and activity of daily living.

When the RSA is used as a treatment for proximal humeral fractures the post-operative clinical outcomes have been shown to be worse.

Zumstein et al. differentiated “complications” from “problems” evaluating events associated with RSAs. Complications have been defined as events affecting clinical outcomes.

Most common complications associated with RSA are: acromial and scapular fractures, instability, aseptic glenoid and humeral loosening, infection, humeral fractures and nerve
injuries. The most common problem is scapular notching. Furthermore, the replacement might change the stress distribution in the proximal humerus, with bone adaptations. The incidence of complications has been changing over time. During the last decade infection seems to be outpacing instability, becoming the first cause of complication [69] [2]. The decreased rate of dislocations might be due to improvements in design and surgical skills.

The acromial and scapular fracture rate ranges from 1 to 4 % [27]. Elderly females with osteoporosis have an higher risk of these fractures. Furthermore, the design of the RSA implanted influences this value: the Grammont RSA is associated with a higher rate. These fractures might be caused by trauma (fall on the ground) or by an increased tension of the deltoid (stress fracture) and have been classified by Levy et al. in three types [56].

Overtensioning the deltoid by distalizing humerus has been shown to be the main risk factor for stress fractures [54] [29] [51]. Lädermann et al. [51] stated that arm lengthening more than 2.5 cm compared with the contralateral side might increase the risk of stress fracture.

The placement of the baseplate superior screw with a direction towards the base of the scapular spine has been advocated as a risk factor for these fractures. Orienting the screw towards the coracoid reduces significantly the rate of scapular fractures [48]. The treatment strategy to be used with these fractures is still controversial. Surgery has not been associated with significant higher postoperative clinical outcomes. A conservative treatment with a sling in abduction for 4 weeks is more frequently used. Operative treatment with plate fixation might be considered in younger patients with high functional demands. This complication lead to inferior outcomes when compared to RSA without any associated fractures [63].

The rate of glenohumeral instability after RSA has been shown to be 1.4 %. [27] With improvements in prosthesis designs the rate of dislocations seems to be reducing. The RSA stability is influenced by soft tissue and impingement free arc range of motion. The risk factors for RSA dislocation are: previous surgery, lack of soft tissue tension, improper version/inclination of the implant [7]. Although this design increases the glenohumeral joint stability, a good soft tissue envelope is mandatory to avoid anterior and posterior dislocations.

The soft tissue tension changes with different RSA designs: in Grammont designs, failure to restore sufficient soft tissue tension may result in prosthetic instability.
The subscapularis which is considered a protector against anterior dislocation in TSA and medialized RSA (Grammont design), might be not necessary in lateralized RSA implants, as the whole compression needed is carried out by the deltoid [21].

In revision surgery, soft tissue tension might be also reduced due to shortening of the humeral height, compared to the normal opposite side (Proximal Humeral Bone Losse – PHBL).

Deltoid and RC tension might be increased by distalizing and/or lateralizing either the glenoid and humerus [29] [42] [34] [20] [52].

The infection rate has been reported by Ascione et al. to be 4.1% [2]. Prior shoulder surgery (e.g. arthroscopic rotator cuff repair), obesity, rheumatoid arthritis, malnutrition and long operation time increase the risk of this complication [7]. Cutibacterium acnes (formerly Propionibacterium acnes) which is the most common pathogen, is normally present on the skin and takes up to 14 days to be detected from the culture [44].

Still debated is the preferred treatment strategy. In acute (< 45 days) infection open irrigation, debridement and exchange of polyethylene might be an option. In chronic (> 45 days) infection, a two stage revision is the gold standard with better clinical outcomes.

Aseptic glenoid loosening may be caused by poor bone stock, excessive version/superior inclination, the design of glenoid component, the technique of fixation and excessive joint reaction forces.

Glenoid bone defect correction is mandatory and might be performed through an eccentric reaming and/or the use of bone grafts (e.g. Bony Increased Offset) or augmented baseplates [18]. Excessive reaming should be avoided as it is associated with subchondral bone weakening with loss of bone volume and surface area. Augmenting the baseplate with bone or metal, preserve bone stock enhancing the baseplate fixation and increasing the implant lateralization.

The central fixation element is the main responsible for baseplate stability. The number of peripheral screws to be placed depends on the design of the glenoid component. Glenoid component failure rate has reduced tremendously after the introduction of locking screws [16]. Optimal screw placement maximizes screw length, accomplishes far cortical fixation, and attains screw purchase in good bone stock [45].

The compressive forces acts on the glenoid side as stabilizers, whereas the shear forces, acts in a direction parallel to the glenoid and might lead to the component loosening [67].
Aseptic stem loosening is not common, occurring more frequently in longer follow-up[33]. No difference has been shown in terms of stem loosening between cemented and uncemented stems.

Nerve injury might be caused by transection (electrocautery), thermal injury (cement extrusion) or excessive compression (e.g. retractors), traction (e.g. arm lengthening, intraoperative positioning), pressure (hematoma). The nerves at higher risk are the axillary, radial, suprascapular and brachial plexus nerves.

Uncommon and difficult to manage, the periprosthetic fractures occur more frequently on the humeral side, during impaction or arm positioning [13]. While treating humeral fractures, it is mandatory to reach the stem stability. With a stable stem, the fracture might be fixed, otherwise the stem should be replaced with a longer cemented one[47].

Scapular notching is due to the humeral socket impinging with the scapular neck in extension, adduction and external rotation with PE erosion, joint inflammation and a higher risk of implant loosening [62] [10,62]. This was a very common radiographic finding with the first RSA designs, with rates up to 96%. A medialized CoR, which is one of the Grammont design characteristic, would increase the risk of this event.

The scapular notching was first reported and classified by Sirveaux[62]. The classification, based on true AP radiograph, divides this phenomenon in five grades: grade 0 : no notch ; grade 1 : notch contained within the inferior pillar; grade 2 : notch extension under the inferior screw ; grade 3 : notch extension over the inferior screw ; grade 4 : notch extension under the peg [49,46,68].

Several factors are associated with a higher risk of scapular notching [60]. The glenoid baseplate version and inclination, the neck-shaft angle, the length of the scapular neck, the position of the CoR [55]. Positioning the glenosphere with inferior overhang, inferior tilt and lateralization has been proposed as the optimal combination on the glenoid side to reduce scapular notching risk [8,5,25,65]. The development of new designs with a lower NSA has decreased the scapular notching rate.
An inferior overhang of the glenosphere might decrease the risk of both this problem and impingement during abduction, due to an increased distance between the greater tuberosity and coracoacromial.

Still debated is whether exists a correlation between scapular notching and clinical outcomes.

The evolution of the humeral component design is continuing with the goal of improving survivorship and patient clinical results. Short uncemented stems have been developed to preserve proximal humeral bone stock and reduce remodelling and bone adaptation.

Still debated is whether bone adaptation and remodelling is more frequently detectable in Onlay than Inlay systems.

The Onlay prosthesis has been criticized due to its non anatomic design, an increased risk of fracture (additional humeral lateralization and distalization), a greater difficulty in suturing the subscapularis. A theoretically increased deltoid wrapping and greater bone stock preservation have been proposed as strengths of this design [4,53]. Furthermore with this system the tray offset might be changed, influencing the position and medio-lateralization of the humerus.

An Inlay implant seems to have better bone integration and thus better humeral fixation with less risk of proximal stress shielding and loosening. Lower deltoid tension is associated with a reduced risk of scapula spine fracture and a lower risk of neurological injuries [43,37].

Return to sports after reverse shoulder arthroplasty is possible and highly frequent with no change or improvement in subjective level of practice in most of the cases[23].

Conclusions

A lateralized glenoid (whether with bone or metal) and a 135° Inlay system configuration leads to a moment arm which is the closest to the native shoulder.

In addition to the intrinsic characteristics of the prosthesis, patient selection remains a fundamental step to get the best clinical outcomes.

Clinical research will focus on implant designs reducing bone adaptations and revision rate, strategies to prevent more effectively infections.

Furthermore, there is still room for improvement in terms of better postoperative internal and external rotations and clinical outcomes after RSA implanted for humeral fracture and revision shoulder arthroplasty.
**Funding:** No funding to report for this submission

Data Availability: Data are available upon reasonable request

Research Ethics Approval: No research ethics approval needed

**Competing Interests:** There are no competing interests for any author

**Contributorship:** Francesco Franceschi, MD, review articles; Edoardo Giovannetti de Sanctis MD write the paper; Alessio Palumbo, MD review articles.; Edoardo Cristalli, MD, write the paper; Mattia Pugliese, MD, write the paper; Leonardo Moreno, MD, write the paper; Giovanni Di Giacomo, MD, review the paper;

Acknowledgments: No Acknowledgments needed

**Disclaimer:** The authors declare that they have no conflict of interest.


Box 1.
Key articles


Box 2. Validated outcome measures and classifications

**Outcome Measures**
- Constant-Murley Score
- American Shoulder and Elbow Score (ASES)
- Pain VAS
- Subjective Shoulder Value (SSV)

**Classifications**
- Walch Classification of Primary Glenohumeral Osteoarthritis
- Favard Classification for different types of sagittal glenoid erosion
- The Nerot-Siveaux Classification for Scapular Notching
- Levy’s Classification for postoperative acromial fractures
- Wright and Cofield Classification for Shoulder Periprosthetic Fracture
Box 3.
Key issues for RSA

Baseplate superior inclination should be avoided
0 to -10° of retroversion
Peg/Central screw and peripheral screws should be placed in good bone stock
Humeral retroversion: 0-30°
Avoid excessive filling ratio when implanting the stem
Suturing the subscapularis when possible

Box 4.
Tips & tricks

• Correct and lateralize as much as possible the glenoid surface whether with metal and/or bone autograft
• Add as many screws as you can to maximize baseplate fixation
• Aim to place the glenoid with a slight inferior tilt
• The 135° neck shaft angle more anatomical, less scapular notching, and favorable
• In order to prevent axillary nerve injury, caution should be used during periosteal detachment in glenoid preparation.
• The use of arm support would decrease the brachial plexus strain
• Avoid excessive traction while placing the arm in excessive external rotation, extension and abduction at risk
• Ream and impact carefully the humeral component to avoid humeral fractures.
• Broaching parallel to the humeral shaft and avoid excessive fitting of the humeral stem
• To prevent periprosthetic infections:
  1. bathing with chlorhexidine gluconate on the day before surgery,
  2. administration of cephalosporin as a preventive antibiotic 1 hour before surgery,
  3. changing surgical gloves regularly,
  4. changing the blade after skin incision,
  5. frequent surgical site irrigation (also with diluted povidone),
  6. injection of gentamicin at the time of closure
7. use of antibiotic-loaded cement (1 g of vancomycin/bone cement)

**Figure Legends**

**Fig. 1.** The BIO-RSA Technique modified by the senior author.

**Fig. 2.** Schematic drawing of the Moment of Force, which depends on both the force (F) and on the position at which the force acts.

**Fig. 3.** Whatever the configuration, the RSA moves the CoR medially.

**Fig. 4.** The LatG/MedH configuration leads to a moment arm which is the closest to the native shoulder.
Fig. 1. The BIO-RSA Technique modified by the senior author.
**Fig. 2.** Schematic drawing of the Moment of Force, which depends on both the force (F) and on the position at which the force acts.
Fig.3. Whatever the configuration, the RSA moves the CoR medially.
**Fig. 4.** The LatG/MedH configuration leads to a moment arm which is the closest to the native shoulder.