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PG 38 **TITLE IX LEGISLATION:** GENDER DIVERSITY TASK FORCE

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INSIDE

Reverse Total Shoulder Arthroplasty

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Introduction

Reverse total shoulder arthroplasty (RTSA) is known to be a functional rather than an anatomical surgical procedure. In fact, it overthrows the normal glenohumeral anatomy by transferring the convex component to the glenoid side and the concave component to the humeral side. The goal is to allow good shoulder function even in the absence of a functional rotator cuff.

RTSA is based on four cardinal principles: (1) the center of rotation must be fixed, distalized, and medialized at the glenoid surface; (2) the deltoid lever arm must be effective from the onset of movement; (3) the prosthesis must be inherently stable; and (4) the construct must create a semiconstrained joint.

The indication for which RTSA was initially developed was cuff tear arthropathy in the elderly, for whom there was a lack of viable surgical treatments for irreparable massive injuries. The indications have expanded over time, and RTSA is now also widely used for the treatment of nonsynthesizable fractures of the proximal part of the humerus[1] as well as massive rotator cuff tears, even those that are not associated with arthropathy.

The design of RTSA implants is constantly evolving, with the goal of minimizing complications and improving range of motion (ROM). Such evolutions have included the development of configurations with medialized or lateralized glenospheres, humeral inlay and onlay components, and neck-shaft angle modifications. The results of these configurations and possible couplings, along with their advantages and disadvantages in each case, were studied in order to find the best compromise of stability and articularity.

Glenosphere Positioning

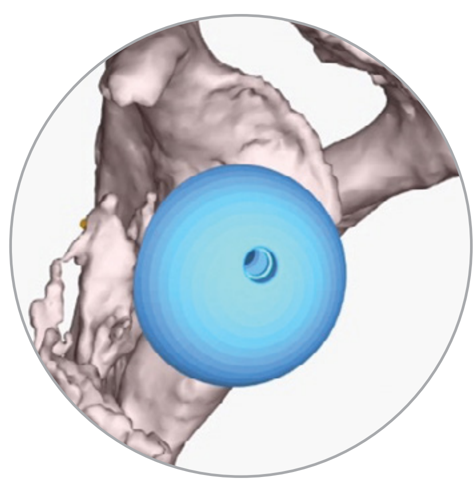
The initial design of the RTSA included a medialized glenosphere (Figure 1) so that the center of rotation was medialized as much as possible. Studies in later years have shown the limitations of this positioning with regard to notching and tensioning of the residual rotator cuff. In actuality, if a medialized glenosphere is combined with an inlay humeral configuration, the residual rotator cuff can become detensioned, resulting in worsened ROM in internal and external rotation and less deltoid wrapping, reducing the horizontal stabilizing force and potentially increasing the risk of dislocation.

Therefore, several techniques have been developed over the years to lateralize the glenosphere in order to achieve greater tensioning of the infraspinatus and teres minor, thereby improving the capacity for internal and external rotation. Other advantages associated with this configuration include a reduced incidence of scapular and humeral impingement and a greater ability of the deltoid to horizontally stabilize the implant, reducing the risk of dislocation.

Lateralization can be achieved with different techniques and components. A bone augment, usually taken from the head of the humerus before osteotomy, can be implanted on the glenoid along with the baseplate. This is also very useful to compensate for any bony defects in the glenoid. This technique, known as bony increased offset reverse shoulder arthroplasty (BIO-RSA), maintains the center of rotation inside the bone. Lateralization of the glenoid component can be achieved with use of metal augments and eccentric lateralizing glenospheres.

Inferior eccentricity is another parameter that can contribute to the improvement of ROM while reducing inferior scapular notching.

Today, harnessing the different techniques, most prosthetic implants are implanted with a lateralized and inferiorly eccentric glenosphere.



01 Glenosphere in its position on the glenoid.

BIO-RSA and Angled BIO-RSA

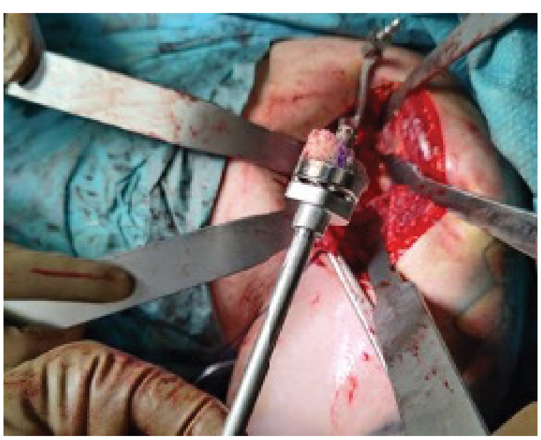
The topic of BIO-RSA (mentioned above) deserves further investigation as it is a very peculiar technique. In several cases, the glenoid has bone deficits that should be corrected in order to maximize baseplate fixation and overall function of the prosthesis. Walch type-A2, B2 and C and Favard type-E2 and E3 glenoid often are treated with asymmetric reaming and sometimes with an augment. In the past, the only chance to correct the bone defect was through autologous iliac crest harvesting, a very invasive technique, or through metal-augmented baseplates.

Recently, a new and innovative technique to obtain an autologous graft while minimizing invasiveness for the patient has gained ground. This technique involves harvesting an autologous graft from the head of the humerus (Figure 2); the graft can be symmetrical or asymmetrical, depending on the bone defect and angle to be corrected. Boileau et al. evaluated a technique termed angled BIO-RSA, which involves the use of a nonsymmetrical graft that allows filling of the bony defect in the glenoid while restoring the proper angle, allowing for less notching, improved deltoid wrapping, and an overall more efficient prosthesis[2].

Angled BIO-RSA allows for the correction of multiplanar defects, such as major version and tilt deformities, that cannot be corrected by asymmetric glenoid reaming. In the case of particularly large defects that exceed 25% of inclination or retroversion, CT planning with three-dimensional (3D) reconstructions may also be used to assess the size and shape of the graft to be harvested.

Baseplate fixation with graft addition requires a rather long central peg as well as appropriate screws. Postoperative CT scanning can be used to assess the integration of the graft, the presence of notching, and the effective correction of the bone defect.

In conclusion, according to Boileau et al. and our experience, the humeral graft provided optimal integration and correction of the deformity, allowing patients to achieve results comparable to those with a defect-free glenoid.



02 Autologous graft taken from the humerus, shaped and implanted on the baseplate.

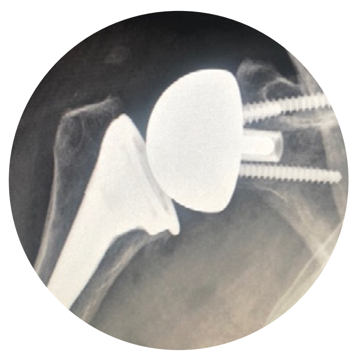
Humeral Stem Design

Inlay vs. Onlay

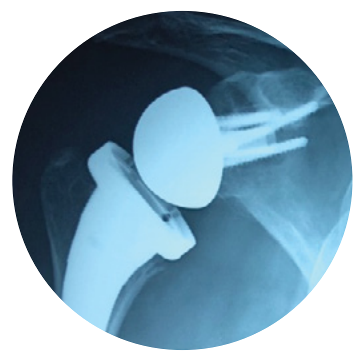
The main stem configurations involve either an inlay (Figure 3) or onlay (Figure 4) design. With an inlay design, reaming of the proximal part of the humerus is performed and the humeral tray is seated within the metaphysis, eroding the bone stock and the tuberosities. With an onlay design, the humeral tray lies on the osteotomy of the proximal part of the humerus, achieving lateralization of the humerus while preserving the bone stock. Lateralization on the humeral side increases the lever arm, improves the deltoid wrapping and decreases the incidence of notching, maintaining the center of rotation inside the bone.

Opting for a humeral inlay component reduces residual rotator cuff tension and deltoid tension, affecting internal and external rotation. Conversely, the onlay configuration leads to more tension in the cuff and deltoid, providing better ROM.

Larose et al. performed a meta-analysis to evaluate the differences and outcomes of the two designs, including movement in all planes of motion and the incidence of complications[3]. This analysis involved 12 studies evaluating the outcomes of the two different configurations with use of the American Shoulder and Elbow Surgeons (ASES) score, ROM, complications, and postoperative benefits. Both groups of patients showed significant improvement in terms of symptoms and range of motion. The inlay design proved superior in terms of the ASES score. Although the onlay configuration was statistically superior in terms of ROM, this difference was not clinically important. The onlay design demonstrated a lower incidence of notching but a higher incidence of scapular spine fractures.



03 Inlay stem



04 Onlay stem

Short Stem vs. Long Stem

The length of the humeral stem is an important factor for multiple reasons. Proper stem sizing provides stable integration or cementation and optimal load and force distribution. Stem length also affects the preservation of bone stock. Optimal placement is also important to maximize the achievable ROM.

Reverse Total Shoulder Arthroplasty

Erickson et al. evaluated a long stem and a newer short stem configuration[4]. Both stems allow for the use of a modular cup and either a 155° or 135° humeral inclination angle. The study was performed with use of the 135° cup. After a minimum follow-up of two years, they evaluated both component integration and clinical outcomes. The short stem was associated with superior clinical results, excellent integration characteristics, less sacrifice of bone stock, and slightly better outcomes in terms of rehabilitation and ROM. In addition, this component is less problematic in case of an eventual revision surgery.

Neck-Shaft Angle

Another important humeral parameter is the neck-shaft angle (NSA), which is calculated by measuring the direct angle between the normal vector of the anatomic humeral head osteotomy plane and the humeral canal axis. The original Grammont design, which remained in use for many years, had a 155° NSA. Subsequently, in addition to the already discussed changes in humeral stem shape and positioning, the NSA was also modified in an effort to offer increasingly high-performance prostheses with better ROM.

Arenas-Miquelez et al. analyzed changes in ROM in the different planes with different stem and NSA configurations[5]. Changes were found to be clinically important and statistically significant. Inlay, semi-inlay, and onlay stems were used for the trial. In the case of semi-inlay stems, increasing the NSA angle produced an increase in abduction.

In contrast, as NSA angle increased, adduction decreased consensually. On the other hand, when analyzing the ROM meant as the sum of abduction and adduction, the result was shown to be similar for each NSA angle. Flexion, extension and combined ROM were found to be superimposable for all three NSA angles considered. Tests of internal and external rotation, performed with the arm at 10° of abduction, demonstrated different results depending on the configuration, with a progressive increase in both values and thus in overall ROM from 155° to 145° and finally to 135°.

Conclusions

There continues to be great fervor in trying different designs, placements, and configurations in order to achieve increasingly satisfactory results. As previously stated, the ideal design of the reverse prosthesis is still the subject of study and discussion. There is now unanimous agreement that lateralization of the glenosphere and thus the center of rotation has advantages, whereas humeral design variations are the subject of continued work and debate.

For some features, there is still no unanimous consensus, but great advances have been made in improving overall ROM, reducing notching, and reducing adverse events such as acromial and scapular spine fractures. Certainly, the lateralized position of the glenosphere and its inferior eccentricity have made great contributions to improving ROM, and these concepts now have a solid background in the current literature. Currently, regarding the other configurations, the choice of the best compromise for the individual patient is left to the surgeon.

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