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Contemporary use of reverse total shoulder arthroplasty

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ABSTRACT

Reverse total shoulder arthroplasty (RTSA) has evolved as the treatment for glenohumeral joint disease in patients with rotator cuff pathology because it allows for the deltoid to be further recruited during abduction. Surgical procedure for an RTSA can be done via two approaches, deltopectoral and superolateral. The most commonly reported complications include infection, dislocation, humeral fracture, glenoid fracture, hematoma, neurological damage, implant loosening, and scapular notching. The RTSA has become prominent in the treatment of shoulder pathology due to its ability to treat a gamut of complex disorders, while awarding pain relief and enhanced functional range of motion.

1. Introduction

In the late 1980s, Paul Grammont introduced a game-changing design for the reverse total shoulder prosthesis that was based on four core principles, listed as follows: (1) the center of rotation must be fixed, medialized, and distalized with respect to the glenoid surface, (2) prosthesis must be inherently stable, (3) the lever arm of the deltoid must be effective from the initiation of the movement, and (4) the glenosphere must be large and the humeral cup small to create a semi-constrained articulation [1,2]. Although Grammont's principles have been the mainstay, the modern prosthetics have been modified to avoid scapular notching, impingement between the greater tuberosity and the coracoacromial arch, and maximize compressive forces while minimizing shear forces [2,3]. Between 2006 and 2011, the utilization of reverse total shoulder arthroplasty (RTSA) nearly tripled and continues to rise [4]. RTSA has gained popularity with its ability to alleviate pain and increase range of motion in patients with glenohumeral joint disease and rotator cuff tear arthropathy, severe irreparable rotator cuff tears, rheumatoid arthritis, or failed shoulder arthroplasty [1–3,5].

RTSA has evolved as the treatment for glenohumeral joint disease in patients with rotator cuff pathology because it allows for the deltoid to be further recruited during abduction, compensating for the dysfunctional rotator cuff [2,3]. This is accomplished through moving the joint's center of rotation medially and distally, which lengthens the moment arm of the deltoid, increases the deltoid's ability to produce torque, and adds tension to the deltoid [1–3]. Additionally, using a larger glenoid component with no neck provides inherent stability while aiding in abduction and adduction of the shoulder joint, decreasing shear forces and the occurrence of notching [3,6].

The surgical technique for RTSA can be done via two approaches, deltopectoral and superolateral; although, deltopectoral is most commonly employed, the approach must be

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determined using surgeon experience and patient factors [3,6,7]. The surgical technique begins with an incision overlying the deltopectoral interval, preserving the cephalic vein, then tenotomizing the biceps tendon and the subscapularis if still intact [3,6,8]. Next, the joint capsule is circumferentially released and humeral head exposed to perform a humeral head osteotomy. The humeral head is then reamed and broached. Subsequently, the glenoid is exposed, the labrum excised, and the glenoid prepared. The guidewire for the glenoid reamer is placed inferiorly so that the glenoid baseplate will be flush with the inferior border of the native glenoid rim. This will help decrease the risk of scapular notching. By adding an inferior tilt to the position of the baseplate, the risk of scapular notching can be further decreased, as well as improve compressive forces and avoid shear forces on the glenoid component. The baseplate is impacted in place, and secured with screws to securely fix the baseplate to the patient's native glenoid. The glenosphere that has been chosen is then secured to the baseplate with a Morse Taper fixation mechanism. The choice of which glenosphere to use is multifactorial. It is based not only on the patient's size, 42 mm for larger patients, 39 mm for "average" size patients, and 36 mm for smaller patients, but on individual patient specific pathologies. The glenospheres are available in central, lateral offset, or inferior offset designs.

The humeral stem is prepared, by first "sounding" the inner diameter of the humeral shaft, then broaching to the appropriate size. The final implant is tested with the spacer trials to gain the appropriate amount of stability and motion. Once the construct is determined, the real implants are seated and the shoulder is reduced. Finally, the subscapularis is reattached and biceps is tenodesed with heavy nonabsorbable sutures that are placed through drill holes in the humeral metaphysis prior to seating of the final implant. However, recent research acknowledges the controversy surrounding the reattachment of the subscapularis due to the potential for increasing the likelihood of dislocation [9]. The deltopectoral interval is re-approximated and the incision closed. The patient is placed in a shoulder abduction sling. According to Jarrett et al. [10], a period of immobilization for 2–6 weeks with a home physical therapy program is a suitable plan for a patient following RTSA. As with all orthopedic procedures, the rehabilitation protocol chosen is patient specific. Additional rehabilitation may be considered if the patient needs further strengthening in external rotation [10].

2. Surgical outcomes

RTSA has become prominent in the treatment of shoulder pathology due to its ability to treat a gamut of complex disorders, while awarding pain relief and enhanced functional range of motion [5]. Wall et al. [11] and Roy et al. [12] conducted separate studies, both of which concluded that patients experienced a reduction in pain, and improved functional range of motion in elevation, external rotation, and internal rotation. Although RTSA potentiates major improvements for shoulder pathology, it also poses several complications, with rates ranging from 19% to nearly 60% [5,11–13]. The most commonly reported complications include infection, dislocation, humeral fracture, glenoid fracture, hematoma, neurological injury, implant loosening, and scapular notching [5,11,13]. Additionally, the risk of complications nearly doubles with patients undergoing revision surgery as opposed to primary RTSA surgical patients [11].

3. Rotator cuff tear arthropathy

In a healthy individual, the humeral head is approximately twice as large as the glenoid surface, which allows for a large breadth of functional range of motion. The joint is awarded its stability from tendons, muscles, and ligaments. The rotator cuff provides stability and compressive forces throughout the ranges of motion [3]. However, in a patient with rotator cuff arthropathy, the functional range of motion is often diminished. The supraspinatus is most commonly involved in rotator cuff arthropathy and when deficient, causes the humeral head to migrate superiorly, creating abnormal pressure and wear on the superior glenoid, acromion, and coracoid [3]. The stages of severity of rotator cuff tear arthropathy may be determined using Hamada–Walsh classification system [11,14]. Stage 1 is associated with slight radiographic changes; stage 2 demonstrates diminished subacromial space ($\leq$ 5 mm); stage 3 is demarcated by erosion and "acetabularization" of the acromion as a result of superior migration of the humeral head; stage 4 shows glenohumeral arthritis with acetabularization/femoralization (4a) or without acetabularization/femoralization (4b); and stage 5 is illustrated by humeral head osteonecrosis [11].

4. Component wear and loosening

Nam et al. [3] and Wiater et al. [5] both found that scratching, abrasion, and pitting were the most common modes of damage in the poly components of the RTSA. Damage was observed most frequently in the inferior quadrant, which was attributed to impingement between the scapula and humeral poly component [3]. Component loosening occurred as a result of improper fixation of the glenoid component and inadequate anchoring of a bone graft to native bone [11]. Wiater et al. [5] concluded that damage modes of the components significantly correlated to radiographic and clinical findings; thus, accelerated component wear may lead to premature failure of the RTSA implants.

5. Deltoid engagement

The deltoid muscle plays a major role in the functional range of motion following RTSA; however, excessive load may lead to acromion fracture and chronic muscle fatigue [15]. Overrecruitment of the deltoid increases the load placed upon the joint, which amplifies the risk of implant component wear and failure. Giles et al. [15] measured the effects of humeral component lateralization, glenosphere lateralization, and poly cup thickness, on the joint loading outcomes due to muscle moment arms. They observed that humeral lateralization decreased the deltoid force, glenosphere lateralization