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Anatomic versus reverse shoulder replacement: Are we asking the right questions and what are the answers?

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1. Introduction

Anatomic total shoulder arthroplasty (TSA) has historically been the gold standard surgical treatment of glenohumeral arthritis with an intact rotator cuff; whereas, reverse total shoulder arthroplasty (RSA) has been traditionally performed for advanced rotator cuff tear arthropathy. The main difference between the two is that the anatomic TSA is designed to anatomically reconstruct the glenohumeral joint, and the RSA non-anatomically reconstructs the glenohumeral joint by providing a stable fulcrum via the deltoid in the setting of an insufficient rotator cuff to allow abduction and elevation of the arm.

Pioneered by Charles Neer in the 1970s, the anatomic total shoulder arthroplasty has had excellent results in treating patients with glenohumeral arthritis.[3,30,41] Overall, results of TSA for glenohumeral osteoarthritis are encouraging; however, there remains significant failures in certain groups of patients. In particular, patients with glenoid bone loss, glenoid deformity, and rotator cuff dysfunction are at an increased risk of failure with TSA.

In patients with posterior glenoid bone loss, malpositioned TSA components can lead to increased risk of component loosening, instability and excessive polyethylene wear all leading to catastrophic failure. In fact in 2012, Walch and colleagues demonstrated that a biconcave glenoid wear pattern was a significant risk factor for anatomic glenoid component loosening with 20.6 % of patients developing radiographic glenoid loosening at a mean 77 months follow-up.[48] Similarly, significant glenoid deformity can also lead to increased risk of glenoid loosening and failure. A study of implant retroversion in patients with posterior bone loss and glenoid deformity revealed that retroversion greater than 15° was associated with five times greater odds of osteolysis around the implant at a mean 3.8 years follow-up.[13] Importantly, increased polyethylene wear, glenoid loosening and component failure has been associated with poor self-reported outcomes and patient function.[16]

In addition to bone loss and glenoid deformity, rotator cuff failure is another significant complication of TSA. Data from the Australian Joint Replacement Registry demonstrated early rotator cuff failure as cause for revision TSA in 24.2 % of cases at 2 years.[4] At mid-term follow-up, one study demonstrated an incidence of secondary rotator cuff tear in 16.8 %, and these authors reported a cuff-deficiency survivorship rate of 84 % at 10 years and 45 % at 15 years.[52] In a high-volume single center, at 10-year follow-up after TSA for glenohumeral arthritis, 5.5 % of patients required revision, the majority for rotator cuff insufficiency.[18] Importantly, patients who sustain a secondary rotator cuff tear after TSA have worse functional and clinical outcomes.[22,31,52] Specifically, patients who sustain a subscapularis rupture or lack of healing after TSA demonstrate significantly worse outcomes.[23] And while revision to RSA is a viable treatment option for these patients, it has been associated with increased complications, decreased patient satisfaction and poorer outcome scores compared to performing a primary RSA.[40]

These risks of glenoid component loosening, component failure and rotator cuff insufficiency with TSA led some surgeons to consider use of the RSA as an alternative option for glenohumeral arthritis. In 2013, Mizuno and colleagues published a case series of 27 patients followed for average 4.5 years (range 2–11.6) who underwent RSA for a biconcave glenoid and demonstrated excellent results: one revision for glenoid loosening and 93 % satisfaction rate.[29] This was one of the first studies that demonstrated successful results with the use of RSA instead of TSA in glenohumeral arthritis. Over the subsequent years, this triggered a movement of expanding indications for RSA from rotator cuff arthropathy to include glenohumeral arthritis with or without an intact rotator cuff, glenohumeral arthritis with glenoid deformity and bone loss, massive rotator cuff tears, proximal humerus fractures, tumors and revision arthroplasty.[17]

One early criticism of the RSA was the concern for higher

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complication rates; however, as the use of RSA expanded, implant design improved and complication rates began to decline. This in turn pushed surgeons to consider RSA for glenohumeral arthritis with increasing frequency. And patient outcomes have been promising. In fact, compared to the traditional indication of rotator cuff arthropathy, RSA performed for glenohumeral arthritis has outperformed. RSA done for arthritis is associated with better functional range of motion and patient-reported outcomes when compared to RSA performed for other indications.[37] Furthermore, when comparing outcomes of RSA based on indication, patients who underwent RSA for glenohumeral arthritis had superior function, better patient-reported outcomes, greater post-operative forward elevation and external rotation; and regression analysis confirmed that the preoperative diagnosis of glenohumeral arthritis was an independent predictor of superior outcomes.[44,49] As a result, there has been a substantial increase in use of RSA with glenohumeral arthritis surpassing any other indication for primary RSA[49]

Since the advent of the RSA, it has been clear that the indications have expanded and the complications have improved; however, it remains unclear with certainty if RSA or TSA is the better option for treating glenohumeral arthritis. Both are effective in the management of arthritis with an intact rotator cuff, but there are unique differences in the benefits, complications and outcomes of each treatment option. This has led surgeons to ask the following questions when choosing the appropriate treatment: how do we manage adequate glenoid fixation in the setting of glenoid bone loss and deformity? How do we prevent glenoid component failure? How do we maximize patient functional outcomes, satisfaction and decrease pain while minimizing complications? And how do we maximize outcomes for each individual patient while minimizing their risk of revision surgery?

1.1. How do we manage adequate glenoid fixation in the setting of glenoid bone loss and deformity, and how do we prevent glenoid component failure?

It is evident that management of posterior glenoid bone loss is critical to successful outcomes when performing TSA. Not addressing bone loss and glenoid deformity can lead to high rates of glenoid component loosening and failure.[48] Historically, management techniques such as bone grafting have been associated with poor complication and reoperation rates.[8] Preoperative planning software has enabled surgeons to select the appropriate implant type and size to correct deformity while maintaining the joint line, minimizing bone removal and peg perforations and maximizing backside contact to ensure adequate glenoid component fixation and prevent loosening and failure.[6] Other options include intraoperative navigation and patient-specific instrumentation to better correct glenoid version and inclination for appropriate glenoid component positioning; however, these technologies incur a significant cost and have not consistently shown a difference in clinical outcomes.[42] Augmented glenoid components can also be used to correct deformity without excessive reaming of glenoid bone and have demonstrated good early and mid-term outcomes.[7,12,20,34,36] There is a limit to the amount of correction obtained with an augmented glenoid component in a TSA, and in particular with significantly medialized and retroverted glenoids (Walch type B3), there is a risk of central peg osteolysis and failure.[12,36]

The risk of glenoid component loosening and failure is significant when performing TSA in cases of glenoid bone loss and deformity. This is of particular concern when considering TSA compared to RSA in glenohumeral arthritis. The RSA has two major benefits when compared to TSA: there is potential for osseous ingrowth on both sides of the joint, and the semi-constrained design allows for function in the setting of rotator cuff insufficiency. The use of central screws, cages, posts and ingrowth surfaces on the glenoid baseplate allows for robust glenoid fixation which may be particularly useful in settings of glenoid bone loss, medialization or deformity. This allows the RSA to have inherently better fixation and decreases the risks of glenoid component loosening and failure seen with TSA. In addition, the semi-constrained design of the RSA infers inherent stability in the face of pathologic soft tissue imbalances, alterations in glenoid version, chronic humeral head subluxation that would lead to failure with a TSA. Lastly, in particularly medialized glenoid wear patterns, the ability to lateralize the center of rotation with the glenoid baseplate can restore joint mechanics and improve stability.

This potential for robust glenoid fixation and independence of rotator cuff function make RSA an appealing option in patients with glenoid bone loss, deformity and an insufficient rotator cuff that could lead to TSA failure. And these benefits have been demonstrated clinically. Patients with glenohumeral arthritis with biconcave glenoid morphology, pathologic retroversion and posterior humeral head subluxation demonstrate significant improvements in pain, motion, functional outcome scores and have decreased risk of glenoid loosening and lower complications when managed with an RSA compared to TSA.[34,47]

1.2. How do we maximize patient functional outcomes, satisfaction and decrease pain while minimizing complications?

When comparing TSA to RSA for glenohumeral arthritis, it is important to consider each individual patient's goals, activity level and risk profile to maximize outcomes and minimize complications. Studies comparing TSA to RSA directly have shown largely equivalent outcomes though with a different complication profile. A large study of 2693 TSA and 1758 RSA performed for arthritis from 2012 to 2021 demonstrated excellent improvements in patient-reported outcome measures and pain scores at 1, 2 and 5-years post-operatively with no clinically meaningful differences between the two treatments.[15] Other studies have shown similar improvements in clinical outcomes and pain for both RSA and TSA, though consistently report significantly better internal rotation in patients undergoing TSA compared to RSA.[5,11,45] This difference in internal rotation is of unclear clinical significance, as patient satisfaction remains largely the same between the two groups.[43]

Some studies have shown complication rates to be similar between TSA and RSA. When directly comparing matched cohorts of patients undergoing TSA versus RSA for arthritis, the overall complication rate was 4.5 % with no significant differences between the two groups.[19] One study of patients with glenohumeral arthritis undergoing RSA or TSA revealed overall early complication rates of 10.2 % for TSA and 9.9 % for RSA.[43] Furthermore, yet another study comparing RSA and TSA for patients with arthritis demonstrated equivalent functional outcomes, improved pain scores, high satisfaction and nearly equivalent complication rates (13.7 % TSA, 12.1 % RSA) and decreased reoperations in the RSA group (3.0 % versus 6.9 % TSA).[51] Several other studies actually reveal a lower rate of complications and revisions in RSA compared to TSA performed for glenohumeral arthritis and a decreased revision risk in females with arthritis.[9,25,32,33]

Where these two treatments differ most are the types of complications. As discussed previously, the complications more unique to TSA include glenoid component loosening and failure as well as rotator cuff insufficiency. The most common complications for RSA include scapular stress fracture and instability.[32] Scapular spine and acromion fractures are a particularly challenging complication and can lead to malunion, nonunion, pain and disability; however, the risk is significantly higher in patients who have undergone RSA for rotator cuff arthropathy and less risk in patients treated with RSA for arthritis.[27] Importantly, data has shown that some patients may be treated non-operatively and remain satisfied with their outcome.[26]

It is important to understand each patient's risk profile. For example, patients who undergo RSA that have decreased postoperative internal rotation are more likely to have worse preoperative internal rotation, smoke or are male.[14] Patients who undergo RSA for rotator cuff arthropathy are at increased risk of instability, and patients with osteoporosis are at higher risk of scapular stress fractures.[24] And patients with greater preoperative shoulder range of motion risk losing some motion after RSA and are at increased risk of dissatisfaction after RSA.[39]

Patients who have depression, increased medical comorbidities, smoking, higher self-reported allergies, prior ipsilateral shoulder surgery and chronic opioid use are at increased risk of poorer outcomes after RSA and TSA.[2,19,50] This underscores the importance of addressing modifiable risk factors, setting appropriate patient expectations and identifying risk factors for dissatisfaction, complications or revisions.

1.3. How do we maximize outcomes for each individual patient while minimizing their risk of revision surgery?

An analysis of the Australian Joint Replacement Registry for TSA versus RSA in glenohumeral arthritis reported the 10-year revision rate as 12 % in TSA compared to only 6 % in RSA. It is important to acknowledge that these data include all glenoid component types which have significantly different revision rates. For example, revision rates are increased for metal-backed glenoid components compared to all-polyethylene glenoid components, and increased for non-cross-linked polyethylene compared to cross-linked polyethylene.[28] When stratifying the data to account for these differences, the 12-year cumulative revision rates were 8.7 % for TSA with non-cross-linked polyethylene, 4.7 % for TSA with cross-linked polyethylene, and 6.8 % for RSA.[38] An analysis of the United Kingdom's National Joint Registry comparing TSA and RSA for glenohumeral arthritis reported 9-year revision rates of 0.9 % for TSA and 0.4 % for RSA.[46]

What is important to consider is the age, activity level and anticipated life expectancy of each individual patient. As discussed previously, with newer data reporting an increased revision rate of TSA compared to RSA, it is imperative to understand the life expectancy of each individual patient to hopefully avoid the morbidity of revision surgery. Given the overall complication and revision rates, functional outcomes and modes of failure of RSA and TSA, one could conceive of an ideal patient for either treatment. In patients younger than age 60 with primary glenohumeral arthritis, an intact rotator cuff, high activity levels, no significant glenoid deformity, adequate glenoid bone stock and notable life expectancy, a TSA may be considered. In patients older than age 60 with glenohumeral arthritis, lack a functional rotator cuff, have significant glenoid deformity, excessive medialization or poor bone stock, or may not have a long life expectancy that could withstand a revision surgery, an RSA is the preferred treatment.

2. Conclusion

It is evident that both TSA and RSA are viable treatment options for patients with glenohumeral arthritis and can lead to successful outcomes. Expansion of indications, improved design, excellent outcomes and declining complication rates in RSA have led to a massive increase in utilization with RSA now accounting for 75 % of all arthroplasty performed.[10] Interestingly, contrary to the popular belief of avoiding RSA in younger patients, the greatest increase in incidence of RSA has been in male patients and those aged 50–64.[1] This further highlights the expanding indications and benefits of RSA even in a younger population. At present time, only about 24 % of RSAs are performed for their historic indication of rotator cuff arthropathy, likely a result of excellent outcomes for RSA in glenohumeral arthritis.[21] Modeling predicts that shoulder arthroplasty will increase 122 % by 2040, with TSA increasing by 49 % and RSA by 122 % by 2025 with increased utilization in all age groups as indications for RSA expand and outcomes remain promising.[35]

It is prudent that surgeons understand each individual patient's anatomy to characterize glenoid bone loss, deformity and rotator cuff integrity as well as patient goals, expectations, age, risk profile, activity level and anticipated life expectancy. Surgeons should be asking which treatment will ultimately maximize each individual patient's functional outcomes and satisfaction, decrease pain, minimize complications and revision and provide them a functional shoulder with an implant that will ideally outlive them.

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