

What are the options for shoulder replacement today?

Anatomic total shoulder replacement continues to provide excellent outcomes in cases of advanced osteoarthritis, while reverse total shoulder replacement is being used for some less common clinical scenarios.

ABSTRACT: Pain from osteoarthritis or rheumatoid arthritis has traditionally been the main indication for shoulder replacement. Improved outcomes for this procedure mean other conditions are now being treated with shoulder replacement as well. These conditions include avascular necrosis, rotator cuff tear arthropathy, acute fracture, and posttraumatic deformity. Surgical options for shoulder degeneration include hemiarthroplasty (replacing the humeral head alone), anatomic total shoulder arthroplasty (replacing the humeral head with a ball component and the glenoid with a socket component), and reverse total shoulder arthroplasty (replacing the humeral head with a socket component and the glenoid with a ball component). Anatomic shoulder replacement for osteoarthritis provides excellent outcomes that match those of hip replacement. Outcomes for hemiarthroplasty are more unpredictable, while reverse shoulder replacement

may have higher complication rates, and more long-term outcome studies are needed to explore the risk of complication with this procedure. Absolute contraindications for shoulder replacement of any kind include a nonfunctional deltoid muscle, active infection, and Charcot arthropathy. Possible complications include infection, neurological injury, periprosthetic fracture, and rotator cuff failure. Postoperative protocols for rehabilitation vary among surgeons, but most patients gradually return to all activities over 4 to 6 months. In the long term, patients with a shoulder replacement are discouraged from engaging in activities that involve strenuous lifting or risk of falling. Like hip, knee, and ankle replacements, shoulder replacement has been evolving to address pain caused by joint degeneration. Advances in surgical technique and implant design now allow us to treat patients with a variety of problems.

History

Shoulder arthroplasty was first described in 1953 for the treatment of a fractured humeral head.¹ Experience with replacing the humeral head alone (a hemiarthroplasty) grew over the years, and reports on several clinical series were published in the early 1970s.

During the 1970s and 1980s, clinical experience expanded to include replacing the humeral head with a ball component and implanting a socket component in the glenoid cavity (an anatomic total shoulder replacement). Experience was also gained in reversing the normal anatomy by replacing the humeral head with a socket component and implanting a ball called a glenosphere in the glenoid cavity (a reverse total shoulder replacement).

Since the early decades of shoulder replacement, many different implant designs have been developed and used. Currently, anatomic total

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shoulder replacement is the standard of care for advanced shoulder osteoarthritis, while reverse total shoulder replacement is used for many challenging clinical scenarios, and some situations still call for performing hemiarthroplasty and replacing the humeral head alone.

Indications and outcomes

In keeping with the line of thought for other major joint replacements, the primary indication for shoulder replacement is pain. Shoulder arthroplasty can be undertaken to treat the symptoms of advanced osteoarthritis, inflammatory arthritis, postcapsulorrhaphy arthropathy, avascular necrosis, acute fracture, or posttraumatic deformity. In general, surgery is considered when the humeral head is no

longer able to provide a suitable load-bearing surface to articulate with the glenoid. Glenoid problems are usually secondary or coincident with the humeral problems. Shoulder replacement may also be considered in select cases of massive rotator cuff tendon tears, or for uncommon tendon tears or arthritis combined with instability.

Although approximately one shoulder replacement is performed for every thirty hip and knee replacements,² this less commonly performed procedure has similar clinical success rates. Some patients and physicians wrongly believe that shoulder replacement outcomes are marginal, a misconception based on the frequently poor functional outcome after hemiarthroplasty for fracture.³ In fact, for routine advanced shoulder

arthritis, the outcomes for anatomic total shoulder replacement are excellent and match those of hip and knee replacement.

Osteoarthritis

Advanced osteoarthritis is the most common diagnosis leading to shoulder replacement. As with hip and knee replacement, the procedure is an option for patients when nonoperative treatment has failed. Surgical candidates typically have pain and difficulty with activities of daily living, pain at rest, and/or pain at night.

Historically, hemiarthroplasty has been the surgical treatment of choice for osteoarthritis,⁴ but the results can be unpredictable when the humeral head alone is replaced.⁵ By replacing the humeral head with a



Figure 1

Anatomic total shoulder replacement consisting of a typical uncemented stemmed humeral component and a polyethylene glenoid component cemented in place. The glenoid component is radiolucent and not visible on the radiograph, but cement can be seen around the three glenoid pegs, and a metallic marker embedded in the central peg (arrow) can also be seen.

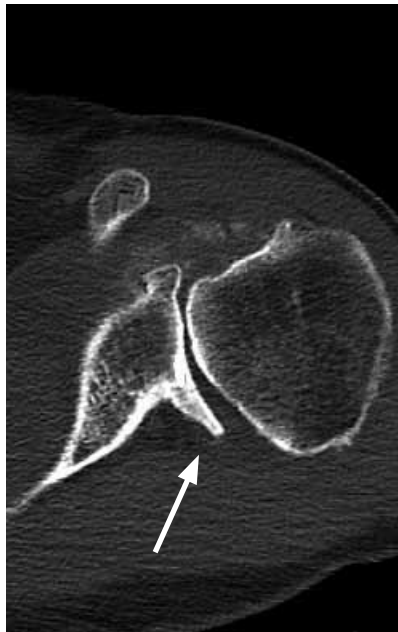


Figure 2

Arthritic shoulder with a biconcave glenoid. This axial view CT image reveals that the posterior glenoid is eroded (arrow) and the humeral head subluxed posteriorly from the anatomic position. Progressive degenerative arthritis often leads to anterior capsular contracture and eccentric posterior glenoid wear.



Figure 3

Metal ingrowth portion of an uncemented monoblock glenoid component. The longer polyethylene portion of the glenoid component is radiolucent and not visible on the radiograph.

ball component and the glenoid with a socket component, anatomic total shoulder arthroplasty (**Figure 1**) has been found to relieve pain and substantially improve shoulder function and overall quality of life.⁶

An anatomic total shoulder replacement requires intact rotator cuff tendons or a repairable rotator cuff tear with good quality tendon tissue. A full thickness rotator cuff tear in the presence of advanced osteoarthritis is uncommon but does occur in 8% of cases.⁷ When compared with hemiarthroplasty, total shoulder replacement has been shown to provide more reliable and better pain relief, and greater improvements in motion. When considering time to revision surgery as treatment failure, total shoulder replacement also has the best long-term survivorship (implant life span). In a recent 20-year follow-up study of patients younger than 50 who underwent shoulder arthroplasty, the 20-year implant survivorship was 75.6% for hemiarthroplasty and 83.2% for total shoulder replacement.⁸

Many patients with osteoarthritis will have some degree of increased and asymmetrical posterior glenoid wear that gives the appearance of a biconcave glenoid (**Figure 2**). Deciding how to manage the glenoid deformity caused by eccentric wear is an important consideration in the treatment plan. In most cases, this can be accomplished by reaming bone from the anterior side to correct the orientation (version) of the glenoid. The current standard of care requires cementing the glenoid component in place, since previous experience with modular uncemented glenoids has been unfavorable.⁹ There is also now the option of using an uncemented monoblock glenoid (**Figure 3**) that has the polyethylene molded into the metal implant rather than mechanically snapped in place as is the case with modular

implants. While this has some theoretical advantages for longevity,¹⁰ no long-term studies have confirmed the superiority of monoblock implants and research is continuing.

For younger patients, covering the glenoid with a soft tissue graft (interposition arthroplasty) has been described. However, recent studies have shown a high failure rate with this procedure and it has fallen out of favor over the last few years.¹¹ In an effort to conserve glenoid bone in a younger patient, a hemiarthroplasty may be performed and the glenoid alone may be reamed out rather than replacing it with a glenoid component. While this has the theoretical advantage of correcting the glenoid deformity while preserving bone, there are few results from long-term studies, and outcomes may be more unpredictable than those for traditional total shoulder replacement, whether there is a glenoid deformity or not.^{5,12}

Patients formerly limited by the effects of osteoarthritis can gain an average of 31 degrees of elevation after hemiarthroplasty, as opposed to an average of 43 degrees after total shoulder replacement.¹³ The functional outcome of total shoulder replacement is also superior to that of hemiarthroplasty. On average, patients who undergo total shoulder arthroplasty have only a slight restriction in activities and are reported to be able to do work above shoulder level. In

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contrast, patients who undergo hemiarthroplasty are able to do most activities of daily living but are not able to do work above shoulder level.¹³ Rather than using a stemmed component, hemiarthroplasty may be done with a resurfacing implant or a stemless implant (**Figure 4**). These newer implants are designed to minimize bone loss on the humeral side, but since humeral loosening is an uncommon problem, techniques designed to prevent humeral revision may be of limited value.

Although uncommon with osteoarthritis, large or massive chronic rotator cuff tears or significant rotator cuff tendon and muscle atrophy can



Figure 4

Hemiarthroplasty using a stemless component.



Figure 5

Reverse total shoulder replacement consisting of a glenosphere placed on a glenoid base plate and a humeral head component with a concave polyethylene liner that is radiolucent and cannot be seen on the radiograph. As the deltoid muscle pulls up on the humerus, the humeral component can rotate around the glenosphere and the lack of rotator cuff function is not a problem. Unlike the humeral head in an anatomic shoulder replacement, which subluxes superiorly, the humeral head in a reverse shoulder replacement rotates along the axis of the glenosphere and allows shoulder elevation with the pull of the deltoid muscle.

develop. If the rotator cuff will not function reliably to keep the humeral head centred in the glenoid, then a traditional glenoid socket component should not be placed as it will loosen prematurely.¹⁴ In such cases, either a hemiarthroplasty or a reverse total shoulder replacement (**Figure 5**) should be considered. Reverse total shoulder replacement can also be considered for cases where bone grafts may be needed to address glenoid deformity, and where instability is more likely to occur after anatom-

ic shoulder replacement.¹⁵ Reverse shoulder replacements tend to be much more specialized, are much more expensive, and have higher complication rates. They should only be performed by surgeons with substantial experience with this operation.

Overall, anatomic total shoulder replacement with a glenoid component appears to offer the best and most predictable pain relief, function, and long-term outcome for patients with osteoarthritis and an intact rotator cuff tendon. Newer options can be discussed with younger patients, and hemiarthroplasty can be considered in select cases. If the glenoid is excessively worn or the rotator cuff tendons are torn, reverse total shoulder replacement can be considered.

Inflammatory arthritis

Rheumatoid arthritis is the most common inflammatory arthritis leading to shoulder arthroplasty, but other inflammatory arthropathies and crystal arthropathies can also lead to advanced joint destruction. The pattern of bone wear usually differs from the wear seen with osteoarthritis, however, and the bone tends to be more osteopenic. Still, the same surgical decision-making strategies used for osteoarthritis can be employed, and similar outcomes can be expected.¹⁶

The integrity of the rotator cuff tendons is an important consideration with shoulder replacement surgery, and patients with inflammatory arthropathies are more likely to have torn rotator cuff tendons or thin and atrophic tendons. Patients with deficient or questionable rotator cuff tendons are generally better candidates for either hemiarthroplasty or reverse total shoulder replacement, depending on preoperative function, age and activity level, glenoid wear pattern, and patient expectations.¹⁷

Postcapsulorrhaphy arthropathy

Postcapsulorrhaphy arthropathy is a form of secondary arthritis that can develop after a shoulder stabilization procedure for anterior instability with excessive anterior capsular tightness. Such procedures were typically used in the remote past and are no longer performed. Postcapsulorrhaphy arthropathy is unlikely to occur with current operations for instability, but may occur following procedures that have intentionally tightened the anterior capsule and/or subscapularis tendon excessively. This tightening can increase oblique posterior translations on the glenoid and increase glenoid wear posteriorly. The pathologic process that follows is the same as in many routine osteoarthritis cases, and the treatment algorithm is also the same as for osteoarthritis.

Scarring and retained hardware from previous surgery for postcapsulorrhaphy arthropathy can increase surgical complexity, and while patients can achieve improvements in range of motion after shoulder arthroplasty, the degree of improvement is not as great as in patients with routine osteoarthritis. Patient-reported outcomes, however, are comparable to those in cases of total shoulder arthroplasty for osteoarthritis.¹⁸

Avascular necrosis

Avascular necrosis of the shoulder differs from that of the hip in being less likely to involve significant symptoms and being responsive to nonoperative treatment in many cases because of the non-weight-bearing nature of the shoulder joint. When the avascular necrosis involves a large portion of the humeral head, there is a higher chance of articular incongruity, collapse of the humeral head, and pain. If avascular necrosis is recognized early in the disease process, it can often be treated using hemiarthro-

plasty alone with excellent short-term and long-term results.¹⁹ However, if secondary degenerative changes have already developed on the glenoid side, then total shoulder replacement should be undertaken. Patients typically obtain excellent pain relief and functional improvement, but the clinical results of shoulder arthroplasty for avascular necrosis may not be as good as for routine osteoarthritis.²⁰

Chronic rotator cuff tear with secondary arthritis

Large and unrepaired or unreparable rotator cuff tears can lead to secondary arthritis. Surgeons will most commonly use the diagnostic term “rotator cuff tear arthropathy” for this degenerative condition. Due to the loss of the rotator cuff, which acts as a restraint to superior migration of the humeral head, the humeral head gradually migrates superiorly and ultimately forms an accessory articulation with the acromion, with superior subluxation along the glenoid. Degenerative changes occur first as the humeral head articulates with the acromion. The greater tuberosity at the top of the humerus begins to round and degenerative changes progress. Eventually, the superior glenoid also begins to wear because of the superior subluxation. Acromial degenerative changes also occur, and degenerative or stress fractures of the acromion can be seen occasionally. Advanced cases may present with large subdeltoid effusions, and the humeral head may show signs of collapse with avascular necrosis. Eventually, progressive rotator cuff tear arthropathy will lead to progressive poor shoulder function,²¹ and in some cases can result in pseudoparalysis (active forward flexion less than 90 degrees with full passive motion).

The surgical care for more advanced rotator cuff tear arthropathy

has traditionally been a hemiarthroplasty. This can provide pain relief but does nothing to restore function, which requires rotator cuff sufficiency for proper shoulder elevation and external rotation.²¹

Reverse total shoulder replacement was initially developed to treat rotator cuff tear arthropathy in those patients with poor shoulder function or pseudoparalysis. With the reverse shoulder replacement, rotator cuff function is not required to keep the humeral head centred on the glenoid. The presence of a glenoid hemisphere allows the humeral head, which is replaced with a concave socket, to rotate around the hemispherical glenoid component as the deltoid contracts, thus obviating the need for a functional rotator cuff. Pain relief is more predictable and superior to hemiarthroplasty alone.²² Despite these advantages, reverse shoulder replacement has several limitations. Patients often lose some internal rotation, and reaching behind the back for personal care may become impossible. External rotation typically does not improve since the infraspinatus is torn in many cases. If patients have less than functional active external rotation (external rotation to neutral), a latissimus dorsi tendon transfer can be considered, but this involves more surgical time and the need for postoperative bracing.^{23,24}

Although the initial pain relief and functional improvements can be impressive with reverse shoulder arthroplasty for a chronic rotator cuff tear, patients need to appreciate that they will always perceive some weakness in the shoulder. One multicentre study found that functional outcomes declined gradually after 7 years,²⁵ and an early study of reverse shoulder replacement reported a high complication rate of 19.0% overall (13.0% in primary procedures and 37.0%

in revision procedures).²⁶ However, experience has been gained with this implant over time and a more recent study reports lower complication rates of 7.0% overall (4.3% in primary procedures and 19.0% in revision procedures).²⁷

Acute fractures

Hemiarthroplasty has been used to treat some older patients with significant displacement in three- or four-part proximal humerus fractures. Controversy remains regarding when to use arthroplasty for acute shoulder fractures and which arthroplasty option to use. Surgeons consider several factors when deciding whether arthroplasty is a suitable option: fracture factors (type, comminution, associated dislocation, likelihood that a late reconstruction will be successful) and patient factors (age, activity level, comorbidities, patient preferences after consultation).

The outcomes of hemiarthroplasty for fractures can be quite variable. Although approximately 79% of patients have no pain after hemiarthroplasty for fracture, more than half have a poor functional outcome.³ Hemiarthroplasty remains a useful option in select cases. More commonly these days, nonoperative care is being considered for elderly patients, and reverse shoulder replacement is being considered as an initial treatment²⁸ for younger more active patients. Reverse shoulder replacement for fracture should not be viewed as an emergency procedure that must be performed immediately, and for best outcome the treating orthopaedic surgeon should refer to a tertiary care surgeon with expertise in the procedure.

Posttraumatic arthritis, deformity, and nonunion

Posttraumatic arthritis with minimal deformity can be approached in the

same manner as routine osteoarthritis. When posttraumatic deformity is significant, however, an anatomic reconstruction may not be possible. In the past, osteotomy was combined with implantation of a traditional stemmed humeral component, but this has become less usual now that we know combining osteotomy with hemiarthroplasty or total shoulder replacement essentially converts the proximal humerus to a four-part fracture and the outcome is often poor.²⁹ More often currently, reverse shoulder replacement is used in older patients for a more predictable outcome when there is significant deformity of the proximal humerus.³⁰

When nonunion occurs following trauma, primary open reduction and internal fixation will be considered if there is enough proximal humeral bone. However, many cases of proximal humerus nonunion involve the shaft eroding into the humeral head and development of tuberosities over time. The humeral head may be thin and unreparable. In such cases, either hemiarthroplasty or reverse total shoulder replacement will be considered.³⁰

Instability

In rare cases, older patients may present with a combination of problems, one of which is instability. With massive rotator cuff tears, especially with previous rotator cuff surgery, the proximal humerus can often sublux anteriosuperiorly (anterosuperior instability). Patients may be unaware of the subluxation, or may complain of shifting, but a fixed anteriosuperior dislocation is uncommon. If older patients with subluxation undergo a hemiarthroplasty, instability is likely to persist and the outcome will be unsatisfactory.

Massive rotator cuff tears can also lead to frank anterior shoulder dislocation when the subscapularis

is involved. In younger patients, soft tissue options may be considered for this challenging scenario, although the outcome can be unpredictable. In older patients, rotator cuff tears are often accompanied by some degree of arthritis, and healing of rotator cuff tendons tends to be poor. Reverse shoulder replacement is a more constrained shoulder arthroplasty that does not depend on the rotator cuff, and is an attractive option in such cases.

Contraindications

A nonfunctional deltoid muscle is an absolute contraindication to all shoulder arthroplasties. The deltoid is the prime mover of the shoulder. If the deltoid is compromised due to trauma, neuropathy, or myopathy, function cannot be restored and the chance of instability increases significantly. Other absolute contraindications include active infection, open injuries, and Charcot arthropathy.

Because the shoulder is a non-weight-bearing joint and does not directly affect a patient's mobility or longevity, relative contraindications are also of significant importance. Shoulder replacement is a major open procedure done under general anesthesia. Careful weighing of anesthetic, medical, and surgical risks against potential quality-of-life improvements is needed for patients with significant medical comorbidities and patients of very advanced age.

Shoulder implants are not designed for constant weight-bearing. Patients who use a walker for security and balance alone and can manage with a cane may be candidates for arthroplasty. Patients who use a walker for significant weight-bearing support are typically not candidates for shoulder arthroplasty because they are at high risk for prosthetic loosening and failure, and they cannot usually cope

with a prolonged period of no walker use (ideally 3 months in the author's opinion).

Patients who cannot comply with postoperative recommendations because of dementia, uncontrolled psychiatric illness, alcohol or substance abuse, or walker dependence are at high risk for tendon failures, instability, and poor functional outcomes. These patients are typically strongly discouraged from having a shoulder replacement.

Complications

Infection is one of the more serious and challenging complications. Chronic indolent infections with propionibacteria are now recognized more frequently, and were likely underrecognized previously. The risk of infection is likely higher for shoulder replacement than for hip and knee replacement, and published studies have reported infection rates ranging from 0% to 4%.^{31,32} As with deep infection after hip and knee replacement, reoperation is required along with prolonged IV antibiotics. Often chronic infections are treated in two surgical stages. Propionibacteria have emerged as the most common pathogens in chronic shoulder arthroplasty infections and can be challenging to diagnose.

Neurological injury can be a devastating complication. The incidence of injury to the brachial plexus or a peripheral nerve is approximately 1.8%. Fortunately, most patients recover from these injuries, but permanent deficits are seen in approximately 1 in 10 cases of neurological injury.³¹

Periprosthetic fracture occurs in approximately 2.0% of cases.³² The incidence of anterior instability ranges from 0.9% to 1.8%, and posterior instability occurs in approximately 1.0% of cases.

Rotator cuff failure is another distinct problem that can present early or late. Early failures may be related to avulsion of the subscapularis tendon repair or unrecognized injury to the supraspinatus tendon. Because anatomic total shoulder arthroplasties rely on a functional rotator cuff, and the rotator cuff is prone to degeneration with age, a replaced shoulder is still vulnerable to rotator cuff strains and tears (both degenerative and traumatic). The rate of rotator cuff tearing in shoulder arthroplasty ranges from 1.3% to 7.8%.³²

Upper extremity thromboembolic events are rare, with an incidence rate of only 0.2%, while the incidence rate for lower extremity deep vein thrombosis is 0.5%.³¹

In one study, 4.6% of patients undergoing shoulder surgery for osteoarthritis received a blood transfusion.³³ However, in the author's experience, transfusion is quite uncommon and is needed in less than 2.0% of uncomplicated cases.

Postoperative protocols

Postoperative protocols for rehabilitation vary among surgeons and depend on the shoulder pathology and surgical procedure used. The author's pattern of practice for routine total shoulder replacement begins with a hospital stay of 1 or 2 nights and includes the following activities.

Patients are encouraged to walk on the day of surgery and to go for daily walks thereafter. In the majority of cases, a routine sling is used for comfort, but occasionally an external rotation brace may be required (e.g., in cases of concomitant tendon transfer or posterior instability). Patients do pendular exercises and passive rotation exercises immediately, and 1 to 2 weeks after surgery they begin passive and assisted elevation exercises.

After 4 weeks, the use of the sling is discontinued and patients begin using the affected arm for waist-level activities. After 6 weeks, patients are encouraged to use the affected arm for all light activities, including reaching. Structured physiotherapy begins at this time, and patients are informed that home exercise is critical to achieving motion recovery. A strengthening program can begin at 9 weeks.

After 4 to 6 months, patients gradually return to all activities as their comfort level permits. In the long term, patients are discouraged from strenuous lifting, heavy labor, and activities that put them at risk of a fall or injury.

Summary

Since the first modern shoulder surgeries were performed, total shoulder replacement has evolved to become an orthopaedic procedure with excellent outcomes. For routine osteoarthritis, anatomic total shoulder replacement offers patients clinical success rates comparable to those of hip replacement surgery.³⁴ Hemiarthroplasty may be performed in select cases, but the outcomes are more unpredictable. The reverse total shoulder replacement is a newer procedure that has been successful in cases of poor rotator cuff function and in other challenging scenarios. However, reverse total shoulder replacement may have a higher complication rate and further long-term outcome studies are needed. Absolute contraindications to shoulder replacement include a non-functional deltoid muscle and active infection, while relative contraindications include significant medical comorbidities and very advanced age. Possible complications that may ensue are chronic infection with pro-pionibacteria and rotator cuff failure. Postoperative protocols for rehabili-

tation vary, but most involve a gradual return to all activities over 4 to 6 months.

Competing interests

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