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Uncommon Indications for Reverse Total Shoulder Arthroplasty

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Total shoulder arthroplasty and shoulder hemiarthroplasty have been the traditional method for treating a variety of shoulder conditions, including arthritis, cuff tear arthropathy, and some fracture types. However, these procedures did not provide consistently good results for patients with torn rotator cuffs. The development of the reverse prosthesis by Grammont in the late 20th century revolutionized the treatment of the rotator-cuff-deficient shoulder with arthritis. The main indication for the reverse prosthesis remains the patient with cuff tear arthropathy who has pain and loss of motion. Because the reverse total shoulder arthroplasty produced such good results in these patients, the indications for the reverse prosthesis have expanded to include other shoulder conditions that have previously been difficult to treat successfully and predictably. This review discusses and critically reviews these newer indications for the reverse total shoulder arthroplasty.

Keywords: *Shoulder, Arthroplasty, Arthritis, Fractures, Surgery*

Reverse total shoulder arthroplasty (rTSA) was originally created to address the complex problem of rotator cuff arthropathy. The indications for surgery in that group of patients include pain, loss of motion and decreased function because of the arthritis, and loss of the rotator cuff.[1] Biomechanically, the rTSA provides a stable and fixed fulcrum of the arm for rotation while increasing the moment arm and the resting tone of the deltoid muscle. As a result, the rTSA can often improve arm elevation and abduction despite a nonfunctional rotator cuff.[2] Multiple studies have reported improved pain and function in patients after rTSA for cuff tear arthropathy.[1,3,4]

Because the literature supports the use of the rTSA for rotator cuff arthropathy, in the United States it officially has been approved only for that diagnosis. Other restrictions of the indications for TSA have been suggested by several surgeons.[5-8] Guery et al.[8] suggested that the rTSA should be used only in patients more than 70 years old because of a decline in clinical results at follow-up at 8 years after implantation. Other reported contraindications of the rTSA include axillary nerve damage, and nonfunctioning deltoid muscle and neuropathic joints.[7,9,10]

However, as surgeons gain more experience with rTSA, indications for this procedure are expanding.[11,12] In addition, because rTSA for cuff tear arthropathy has been successful, the indications for its use are gradually increasing to include tumors of the proximal humerus, revision of hemiarthroplasty to rTSA, and revision of failed total shoulder to rTSA.

The goals of this article are to: 1) briefly review the theory behind rTSA design; 2) review the published data on the clinical and functional outcomes of the rTSA; 3) discuss several more uncommon indications (pseudoparalysis, acute proximal humerus fractures, nonunions of proximal humerus fractures, immunologic arthritis-like rheumatoid arthritis, osteoarthritis with severe glenoid bone loss, dysplasia of the shoulder, and chronic fixed dislocations of the shoulder); and 4) review published clinical and functional outcomes of rTSA for the treatment of those uncommon indications.

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WHY REVERSE TOTAL SHOULDER ARTHROPLASTY?

Traditional TSA using an unconstrained prosthesis has been extensively studied and provides excellent pain relief and function.[13-15] In this patient population, there is usually adequate glenoid bone stock, and the tuberosities and remaining rotator cuff tendons are in their usual positions. Loosening of the glenoid component is the most common cause of TSA failure, especially when used in the rotator-cuff-deficient shoulder.

There are several situations in which a standard TSA may not adequately address the abnormality in the damaged or diseased shoulder, including complete tears of the rotator cuff or conditions of malpostioned or malunited tuberosities. These conditions include a comminuted 3- or 4-part proximal humerus fracture, a malunited proximal humerus fracture, or failed arthroplasty in which the tuberosities become detached or were destroyed during the revision surgery. In such incongruent and rotator-cuff-deficient shoulders, the forces that normally counteract the upward component of the deltoid and stabilize the center of rotation of the shoulder are lost; as a result, deltoid contraction tends to cause the proximal shifting of the humerus, rather than the rotatory movement necessary for elevation of the limb.[16] In this situation, unconstrained designs have not been able to withstand the increased stresses that their fixed fulcrum imposed on the bone-prosthesis interface, leading to early failure and abandonment of these designs.[17] In addition, conventional arthroplasty does not typically reproduce the rotator cuff force couples, resulting in anterior-superior escape of the shoulder with loss of motion and loss of function.

The rTSA was developed to restore mobility around a stable center of rotation to allow the arthroplasty to function without a rotator cuff.[18] Unlike previous reverse ball-and-socket designs, the Grammont uses a large hemispherical glenoid component with no neck. This construct means that the center of rotation of the shoulder joint (the center of the sphere) is actually moved to the glenoid bone-prosthesis interface, minimizing torque on the component.[17,18] In addition, the Grammont has a congruent polyethylene humeral cup, implanted with a nonanatomic, more horizontal inclination of 155°, which has the advantage of lowering the humerus, thereby placing the deltoid muscle under tension to provide a stable and biomechanically stronger fulcrum.[17] This stable fulcrum is essential for active elevation in a shoulder with a severely deficient, unbalanced rotator cuff. De Wilde et al.[19] supported this theory with their biomechanical study.

IRREPARABLE ROTATOR CUFF TEAR WITHOUT GLENOHUMERAL ARTHRITIS (PSEUDOPARALYSIS)

When used for cuff tear arthropathy, the rTSA is used primarily for pain relief. In most cases, the patient will see increases in range of motion because of pain relief alone. However, there is a subgroup of patients with massive rotator cuff tears whose major complaint is that they have lost motion. They are unable to lift their arms above shoulder level because of weakness from the tear or they

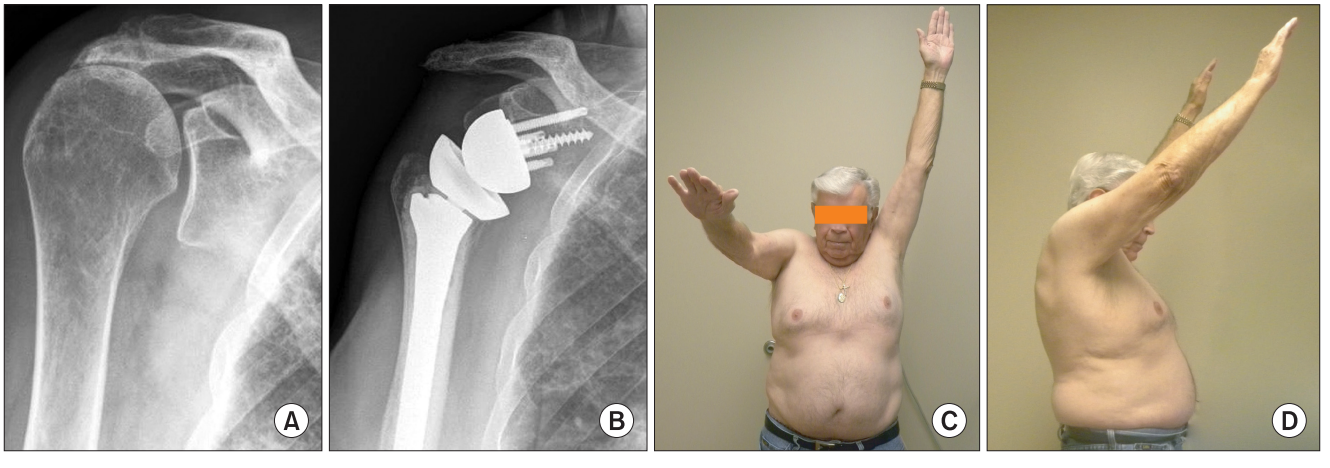

Fig. 1. A 78-year-old male patient with massive rotator cuff tear without arthritis. (A) Preoperative conventional anteroposterior radiograph of the shoulder shows proximal migration of the humeral head without glenohumeral arthritic change. (B) Conventional anteroposterior radiograph of the shoulder at 12 months' follow-up shows satisfactory positioning of the prosthesis with no signs of loosening. (C) Preoperative clinical picture shows active arm elevation at less than 90°. (D) Postoperative clinical picture shows active arm elevation was improved at 12 months' follow-up.

have superior escape where the humeral head does not stay centered in the glenoid with arm elevation (Fig. 1). This condition is called 'pseudoparalysis' because their function is severely limited. These patients typically do not have pain or arthritis. The major goal for the patient with surgical intervention is to restore their motion. Because the return of motion after rTSA is sometimes unpredictable, to perform rTSA surgery on a patient whose only goal is increased shoulder motion can potentially lead to a dissatisfied patient if those goals are not met.

Several studies report results of rTSA for patients with pseudoparalysis.[4,20,21] Wall et al.[4] found no difference in outcomes among a subgroup of 34 shoulders with massive rotator cuff tears and no associated arthritis and a group of patients who underwent a primary rTSA for treatment of rotator cuff tear arthropathy. In a retrospective multicenter study of 42 rTSAs in 40 patients (30 pseudoparalytic shoulders, 12 with a painful shoulder with maintained active anterior elevation over 90°), Boileau et al.[20] found that rTSA could improve function in patients with pseudoparalysis or those with cuff-deficient shoulders after failure of previous cuff surgery. However, they pointed out that in spite of these improvements of function, results were inferior to those of primary rTSA for patients with massive cuff tear or cuff tear arthropathy. Mulieri et al.[21] studied 60 patients with rotator cuff tears and no arthritis; only 16 had pseudoparalysis. They found no significant differences between patients with previous failed rotator cuff surgery and those undergoing rTSA as a primary procedure. However, they did not specifically comment on whether the patients' anterior-superior escape with pseudoparalysis did any better or worse than those without it.

In conclusion, rTSA can be a viable option in patients with loss of shoulder motion secondary to superior escape and pseudoparalysis because of a massive, irreparable rotator cuff tear. However such patients must be counseled that full range of motion may not be obtained and that although shoulder motion may be improved compared with preoperative levels, it may not be restored completely.

ACUTE PROXIMAL HUMERUS FRACTURE

After the first study on hemiarthroplasty by Neer[22] in 1970, it has become the preferred surgical procedure for fractures that cannot be repaired by internal fixation or when the humeral head is deemed nonviable.[23] Recently, long-term studies have identified limitations and a high rate of complications with this procedure such as, progressive decrease in acromiohumeral distance, osteolysis around the humeral stem, and tuberosity reabsorption.[24,25] With longer-term follow-up after this procedure, the outcomes of hemiarthroplasty for fractures of the proximal humerus seem to be inconsistent.[24,25] These studies document that a notable proportion of patients with a hemiarthroplasty for fracture has a stiff or painful shoulder, especially between 2 and 5 years after surgery. Functional outcomes of hemiarthroplasty for these fracture types depend on several factors, primarily the displacement of the tuberosities. Several radiographic measures appear to correlate with poor functional outcomes. Malunion and nonunion of the greater tuberosity could decrease acromiohumeral distance and osteolysis of the tuberosities and result in poor clinical outcomes.[26-29]

Because the functional outcomes of rTSA in patients with proximal humerus fractures (Fig. 2) appear to depend less on tuberosity healing and rotator cuff integrity, patients with rTSA have been observed to recover more quickly after surgery than do patients with a hemiarthroplasty.[2] Several studies about the outcomes after rTSA for proximal humeral fracture have reported favorable results (Table 1).[28,30-36] Bufquin et al.[31] found that the clinical results for rTSA used for proximal humerus fractures were not influenced by the healing of the tuberosities, even though they had 19 patients with displacement of the tuberosities after surgery. Two studies with 22 months (range, 16 to 37 months)[36] and 12.4 months (range, 4 to 18 months)[33] of average follow-up did not identify any significant differences in the clinical results between patients

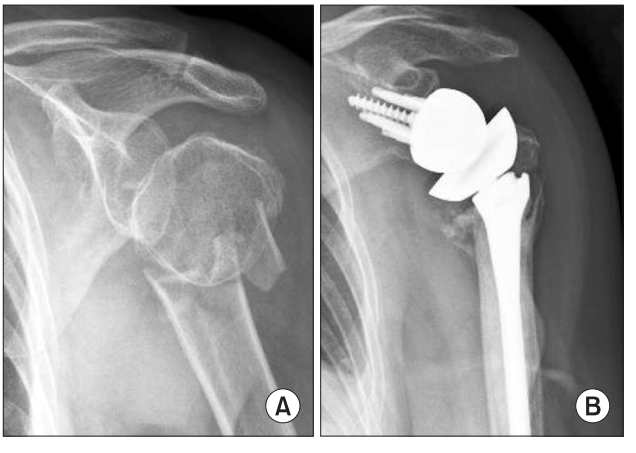

Fig. 2. A 74-year-old female patient with proximal humeral fracture. (A) Preoperative shoulder conventional anteroposterior radiograph of the shoulder shows severe comminuted proximal humeral fracture. (B) Conventional anteroposterior radiograph at 14 months' follow-up shows a well-fixed prosthesis.

with acute proximal humerus fractures treated with hemiarthroplasty or rTSA. However, Boyle et al.[30] and Garrigues et al.[34] found patients with acute proximal humeral fractures who undergo rTSA appear to achieve superior clinical outcomes.

Although some studies have shown good results with rTSA for acute proximal humeral fractures, several studies have cautioned that the results may not be optimum as expected by the patient and surgeon. Smith et al.[12] have pointed out that the outcomes after rTSA for proximal humeral fracture appear to be worse than those achieved in the treatment of cuff tear arthropathy. This conclusion was based on their findings that rTSA patients may still have limited postoperative abduction in the range of around 90° to 100° and that patients showed a wide variation in recovery of external rotation and internal rotation.[12] Cazeneuve and Cristofari[37] have pointed that rTSA for acute fractures show scapular notching, which they cautioned might be a concern with longer-term follow-up because it could contribute to glenoid loosening with bone loss. Bufquin et al.[31] showed a wide variety of postoperative radiographic findings in patients with rTSA, including displacement of the tuberosities, scapular notching, and periprosthetic calcifications. Although these findings did not affect the final clinical result, they cautioned that long-term results are required before rTSA can be recommended as a routine procedure for complex fractures of the upper humerus in the elderly.

Table 1. Summary of Literature of Clinical Results of Reverse Total Shoulder Arthroplasty for Proximal Humerus Fractures

Study	No. of patients	Age (yr)	Follow-up (mo)	ASES	Constant	OSS	DASH	FF (°)	ER (°)	No. complications (%)
Bufquin et al.[31]	43	78 (65–97)	22 (6–58)	9 (0–19)*	44 (16–69)	NA	44 (0–92)	97 (35–160)	30 (8)†	9 (21)
Cazeneuve et al.[32]	36	75 (58–92)	79.2 (12–192)	NA	53 (20–80)	NA	NA	7.5 (5–9)‡	1 (1–4)‡	5 (14)
Boyle et al.[30]	55	79.6 (57–90)	60	NA	NA	41.5	NA	NA	NA	NA
Garrigues et al.[34]	10	80.5 (67–97)	72 (16–96)	81.1 (75–88)	NA	NA	NA	121 (90–145)	34 (10–45)	0
Gallinet et al.[33]	16	74 (58–84)	12.4 (4–18)	NA	53 (34–76)	NA	37.4 (11.7–65)	97.5 (20–150)	9 (0–80)†	2 (13)
Klein et al.[35]	20	75 (67–85)	33 (24–52)	68 (50–90)	68 (47–98)	NA	47 (6–63)	122.7 (60–175)	25 (10–35)	4 (20)
Young et al.[36]	10	77.2	22 (16–37)	65 (40–88)	NA	28.7 (15–56)	NA	115 (45–140)	49 (5–105)	0
Lenarz et al.[28]	30	76.7 (65–94)	23 (12–36)	78 (36–98)	NA	NA	NA	139 (90–180)	27 (0–45)	2 (7)

Values are represented as mean values with ranges except no. of patients and no. of complications.
ASES: American Shoulder and Elbow Surgeons Self-Report score, Constant: Constant-Murley score, OSS: Oxford Shoulder Score, DASH: Disabilities of the Arm, Shoulder, and Hand score, FF: active forward flexion, ER: active external rotation in abduction, NA: not available.
*Contralateral: 21 (16–24). †External rotation with elbow at side. ‡Mean Constant score.

MALUNITED PROXIMAL HUMERUS FRACTURES

In malunited proximal humeral fractures, there is by definition some bony asymmetry that is usually coupled with various degrees of fatty atrophy of the rotator cuff. As a result, the use of a TSA for the treatment of these fractures may be less than optimal because of uneven forces placed across the glenoid component,[38] which can lead to early failure because of the previously described 'rocking horse' mechanism.[39,40] In addition, scar and abnormal function of the deltoid in these malunited fractures may prevent normal kinematics of the standard TSA, resulting in poor motion and continued pain.[38]

Several studies[41-44] have documented these issues (Fig. 3). For example, Antuna et al.[41] reported that 50% of their patients with hemiarthroplasty or TSA for proximal humeral malunion had unsatisfactory results. Boileau et al.[44] reported that the Constant scores[45] after unconstrained arthroplasty for proximal humeral malunion were excellent in 11 cases (16%), good in 19 cases (26%), fair in 18 cases (25%), and poor in 23 cases (33%). They also

found that a greater tuberosity osteotomy was the most likely reason for the poor results.[44]

However, because rTSA does not need accurately positioned tuberosities or rotator cuff, it has been used in the treatment of proximal humerus malunions and nonunions.[17,42] Willis et al.[38] reported rTSA could be indicated for treating the most severe types of proximal humeral malunion instead of unconstrained prostheses. They also found that rTSA would tolerate more extensive soft tissue release for exposure and to increase postoperative motion. They suggested that a greater tuberosity osteotomy is not necessary when placing a reverse prosthesis. Kilic et al.[46] compared the use of standard TSA and rTSA for malunited fractures and found that rTSA led to an improvement in postoperative results. Martinez et al.[47] also reported the rTSA improved function and motion in patients with proximal humeral fracture sequelae, but they reported a high rate of postoperative dislocation because of the combination of additional soft tissue release, deficiencies of rotator cuff tendons, and bone loss.

Although the rTSA may provide some advantages over standard TSA for the treatment of malunited fractures, the results of rTSA when treating this indication are worse than those obtained for rTSA performed for cuff tear arthropathy. Wall et al.[4] reported on rTSA in patients with a wide variety of diagnoses, and those who had rTSA for fracture malunion and posttraumatic arthritis had relatively worse results in Constant score improvement, active range of joint motion, and rate of postoperative complications than those so treated for other causes.

GLENOHUMERAL ARTHRITIS WITH SEVERE GLENOID BONE LOSS

Severe glenoid bone loss can be seen in many shoulder conditions, such as after failed shoulder arthroplasty,

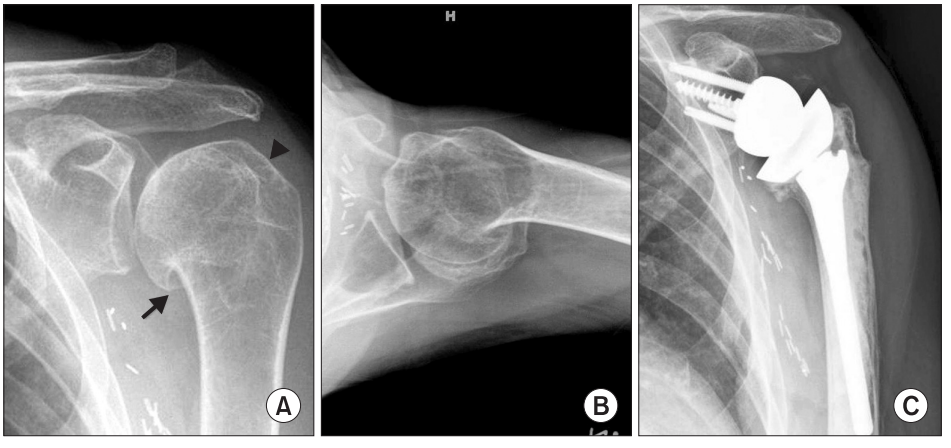

Fig. 3. A 78-year-old female patient with proximal malunited fracture. (A) Preoperative conventional anteroposterior radiograph of the shoulder shows distorted greater tuberosity (arrow head) and inferior part of humeral head (arrow). (B) Preoperative axillary radiograph of the shoulder also shows distorted alignment between the head and shaft. (C) Conventional anteroposterior radiograph of the shoulder at 2 years' follow-up shows a well-fixed prosthesis.

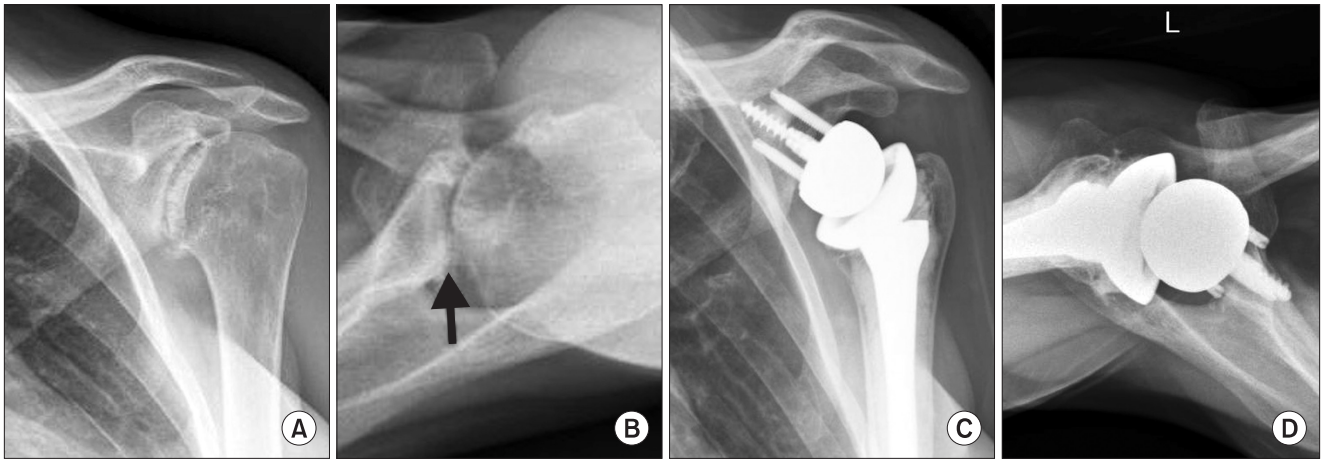

Fig. 4. A 53-year-old male patient with osteoarthritis with glenoid bone loss. (A) Preoperative conventional anteroposterior radiograph of the shoulder and (B) preoperative conventional axillary radiograph of the shoulder show severe bony erosion of posterior glenoid (arrow). Postoperative conventional shoulder radiographs at 25 months' follow-up show a well-fixed prosthesis: (C) anteroposterior view, and (D) axillary view.

inflammatory arthritis, primary osteoarthritis with posterior instability, and chronic glenohumeral dislocations.[48-51] The treatment of this bone loss is controversial, although glenoid bone grafting is recommended for type B2 and type C glenoids.[50,52-56] In most cases of osteoarthritis where the rotator cuff is normal and there is severe bone loss, the conventional treatment is to remove enough bone to make a flat surface for the glenoid component, use bone graft to fill the defect, or do some of both.

One advantage of the reverse prosthesis is that it can often be used in conditions where there is more severe bone loss but bone grafting may not be necessary, particularly in the case of rTSA systems where there is a central screw that may have purchase into bone, which would not be possible with conventional TSA (Fig. 4). Bone grafting with the use of rTSA has also been reported.[57] The authors stated that the hybrid bone grafting (with cancellous autograft and femoral neck allograft) were secured under compression with 2 divergent screws and a minimum of 10 mm of center peg, and that, additionally, the osteoinductive properties of the impacted cancellous autograft promoted early autograft incorporation and ingrowth of the baseplate for rapid, stable fixation of the prosthesis.

We have had limited experience for the use of rTSA in cases of severe bone loss on the glenoid and an intact rotator cuff. There are 2 concerns with this approach. First, medializing the glenoid surface can make the area for implantation of the rTSA baseplate too small for the implant to have good fixation. In this instance, baseplates with a central screw design have more flexibility because they do not require as much bone as peg designs for fixation. The second concern with medializing the glenoid is that the center of axis of the shoulder might be changed enough to alter that mechanics of the prosthesis. In our experience, loosening of the baseplate has not been seen when the prosthesis is used for this purpose; however, long-term follow-up is required before the use of rTSA in patients with glenoid bone loss can be recommended.

SHOULDER DYSPLASIAS

Glenoid dysplasia can occur as an isolated congenital condition in which there are no other joint abnormalities or in conjunction with various conditions such as epiphyseal dysplasia, Kniest syndrome, arthrogryposis, obstetrical trauma, infection, and muscular dystrophy.[58] One study found that 3.5% of patients with primary osteoarthritis undergoing TSA had glenoid dysplasia.[59]

When a patient has a glenoid with substantial dysplasia, it is important to distinguish the hypoplastic glenoid from the type B2 glenoid.[56] In one study, in spite of excessive glenoid retroversion, the humerus and surrounding soft tissues in the dysplastic shoulder appeared to adapt to the glenoid morphology, allowing the humeral head to remain centered in the retroverted socket, and posterior glenoid erosion was minimal in patients with glenohumeral osteoarthritis and dysplasia.[59] There has been little information available about rTSA application for dysplastic glenoid because of the rarity of the disorder. We have successfully used rTSA to treat 1 patient with a

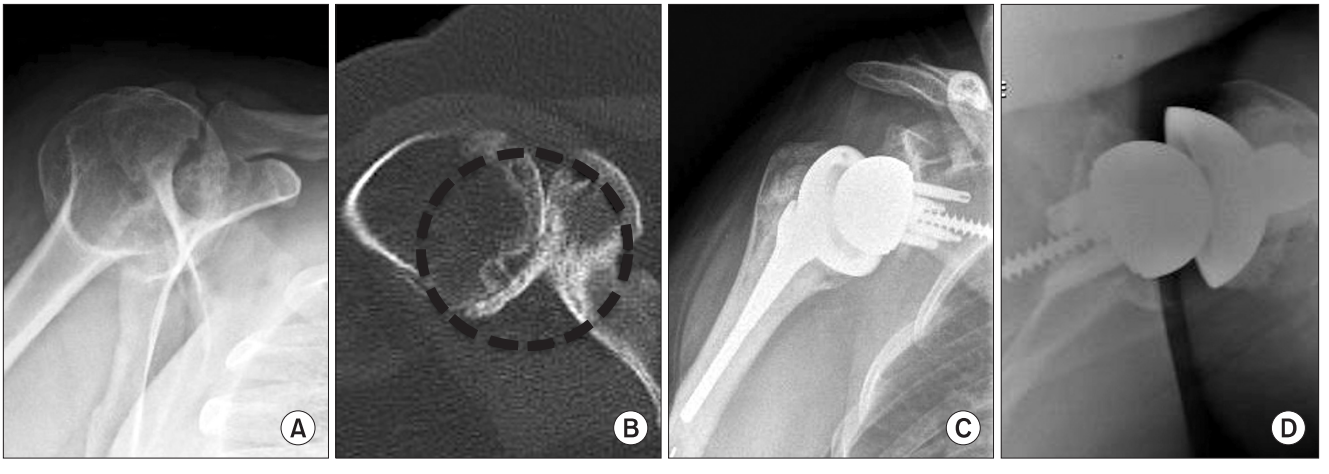

Fig. 5. A 44-year-old female patient with glenoid dysplasia. (A) Preoperative conventional anteroposterior radiograph of the shoulder showing the altered glenoid anatomy, consistent with dysplasia. (B) Preoperative computed tomography scan, axial cut shows narrowed joint space and severely distorted articular surfaces of head and glenoid (dotted circle). Conventional radiographs of the shoulder at 6 months' follow-up show a well-fixed prosthesis: (C) anteroposterior view, and (D) axillary view.

dysplastic glenoid secondary to Kniest syndrome (Fig. 5).

CHRONIC LOCKED DISLOCATION (ANTERIOR AND POSTERIOR)

With chronic glenohumeral dislocation, rotator cuff tears and glenohumeral bone deficiencies may be found in addition to osteoporosis of the humeral head, softening of the articular cartilage, and substantial soft tissue contractures.[60,61] If there is a large humeral head defect (> 50%) or substantial degenerative joint changes, chronic glenohumeral dislocations may require arthroplasty.[60,62] In several studies, TSA has been used for combined large humeral and glenoid bone defects.[63-66] For example, Cheng et al.[64] reported that forward flexion increased from an average of 76.7° (range, 40° to 110°) to 105° (range, 70° to 135°) and that most of the improvement in American Shoulder and Elbow Surgeons Self-Report score was secondary to pain reduction. Checchia et al.[63] reported that 3 of 5 patients with TSA for chronic locked shoulder dislocations had unsatisfactory results.

In patients with chronic, locked shoulder dislocations, there is often a massive rotator cuff tear, a nonfunctioning rotator cuff from greater tuberosity nonunion, or an irreparable subscapularis tear. In addition, there is typically substantial glenoid or humeral head bone loss. To our knowledge, there are no published extensive studies with results of rTSA used for chronic locked anterior dislocation. We have treated 5 patients with chronic locked anterior dislocation (Fig. 6) with rTSA, and although they were not formally studied, their motion and pain have shown improvement and all but 1 were satisfied with the result.

IMMUNOLOGICAL ARTHRITIS WITH OR WITHOUT ASSOCIATED ROTATOR CUFF TEARS

Autoimmune forms of arthritis include rheumatoid arthritis, psoriatic arthritis, inflammatory bowel disease associated arthritis, scleroderma, and ankylosing spondylitis. Although unconstrained shoulder arthroplasty performed in patients with rheumatoid arthritis has been reported to result in good pain relief, improvements in shoulder motion and function were less satisfactory.[67-70] Destruction of the glenohumeral joint resulting from rheumatoid arthritis is also typically associated with rotator cuff deficiency in the form of frank tearing or rotator cuff dysfunction.[71] Secondary rotator cuff failure, resulting in proximal humeral migration, is frequently observed after hemiarthroplasty or TSA.[61,67,72,73] Proximal humeral migration, in turn, is associated with loosening of the glenoid component after TSA.[67,70] Lehtinen et al.[74] studied 74 patients with rheumatoid arthritis for 15 years and found that progressive upward migration of the humeral head was an inevitable consequence of the disease, indicating progressive rotator cuff failure. Therefore, patients with rheumatoid arthritis can develop a condition similar to cuff tear arthropathy.

The use of rTSA for patients with rheumatoid arthritis has been the subject of several studies (Table 2).[49,71,75-77] Two of these studies have shown substantial improvement in range of movement and pain relief with rTSA in this patient population.[76,77] However, at long-term follow-up, there was a high incidence of glenoid radiographic lucencies that raised concerns for the longevity of the glenoid component.[76,77] Because of these concerns, rTSA has not been highly recommended as a satisfactory solution for patients with rheumatoid arthritis.[8,76]

However, 3 recent studies have reported comparatively good outcomes in this patient population (Fig.

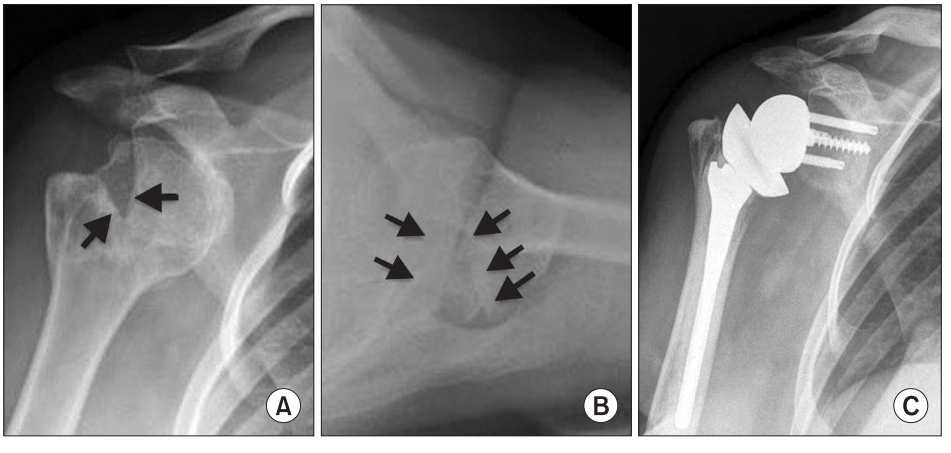

Fig. 6. A 42-year-old female patient with chronic locked anterior dislocation. The anteroposterior (A) and axillary (B) preoperative conventional radiographs of the shoulder show a severe engaged Hill-Sachs lesion (multiple arrows) and unreduced chronic anterior dislocation. (C) Conventional anteroposterior radiograph of the shoulder at 8 months' follow-up shows a well-fixed prosthesis.

Table 2. Summary of Literature Reporting Clinical Results of Reverse Total Shoulder Arthroplasty for Rheumatoid Arthritis

Study	No. of patients	P/R	Follow-up (mo), mean (range)	ASES	Constant	VAS	FF	AB	ER	No. of complications (%)	RR (%)	SN (%)	GL* (%)
Ekelund et al.[75]	27	18/9†	56 (18–143)	NA	13→52	8→1	33→5	26→103	0.6→5.8	4 (15)	3 (11)	14 (52)	0
Holcomb[49]	21	18/3	36	28→82	NA	7→1	52→126	55→116	19→33	4 (19)‡	1 (5)	NA	1 (5)
Young et al.[71]	18	P	45.6 (25–84)	NA	22.5→64.9	4.3→13.1§	77.5→138.6	NA	15→19.7‖	5 (28)	0	10 (55)	0
Woodruff et al.[77]	11 (12 shoulders)	P	87 (60–110)	NA	59¶ (50.5–64.5)	NA	NA	NA	NA	NA	NA	NA	5 (42)
Rittmeister et al.[76]	7 (8 shoulders)	P	54 (48–73)	NA	17→63	NA	NA	NA	NA	NA	3 (38)	NA	1 (13)

Values are mean values.
P/R: primary or revision, ASES: American Shoulder and Elbow Surgeons Self-Report score, Constant: Constant-Murley score, VAS: visual analogue scale, FF: forward flexion, AB: abduction, ER: external rotation, RR: revision rate, SN: scapular notching, GL: glenoid loosening, NA: not available.
*Glenoid loosening or radiolucency. †Hemiarthroplasty 8, total shoulder arthroplasty 1. ‡One glenoid fracture because of trauma after surgery and intraoperative complication are not included unlikely in original article. §Pain score in Constant score. All improvements are statistically significant except ‖. ¶Median value at last follow-up.

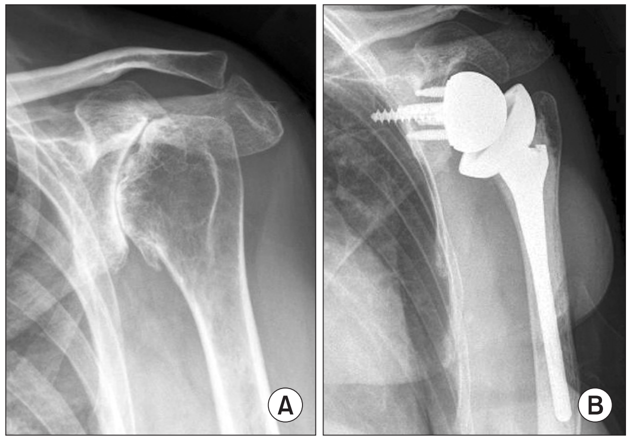

Fig. 7. A 47-year-old female patient with rheumatoid arthritis. (A) Preoperative conventional anteroposterior radiograph of the shoulder shows severely eroded articular surfaces of glenoid and humeral head. (B) Conventional anteroposterior radiograph of the shoulder at 4 months' follow-up shows a well-fixed prosthesis.

7).[49,71,75] Ekelund and Nyberg[75] found no glenoid or humeral loosening in a series of patients with rheumatoid arthritis treated with rTSA. Those authors also found that primary rTSA had better function than that in revision cases and that there was no difference in pain relief at latest follow-up between these 2 groups. Guery et al.[8] also changed their negative opinion about the use of rTSA for rheumatoid arthritis after further study.[71] Previously, they thought that rTSA should not be used for rheumatoid arthritis, but in a subsequent study they found that rTSA performed well in patients with rheumatoid arthritis because the patients experienced not only satisfactory pain relief but also statistically significant improvements in functional shoulder motion. They also found that rTSA would be a good procedure for patients with rheumatoid arthritis, regardless of the status of the rotator cuff, and particularly for patients with that disease who are more than 65 to 70 years of age.[71]

DELTOID DEFICIENCY

Because the success of rTSA depends on an intact and functional deltoid muscle, deltoid deficiency has been a strong contraindication to implantation of this prosthesis.[7,78] Cuff tear arthropathy combined with deltoid muscle deficiency is a rare but extremely difficult reconstructive problem. De Wilde et al.[19] reported that the success of rTSA is reliant on a normal functioning deltoid muscle, primarily the anterior and middle heads. Goel et al.[79] reported on a patient with cuff tear arthropathy and avulsion of middle deltoid who was treated, based on the

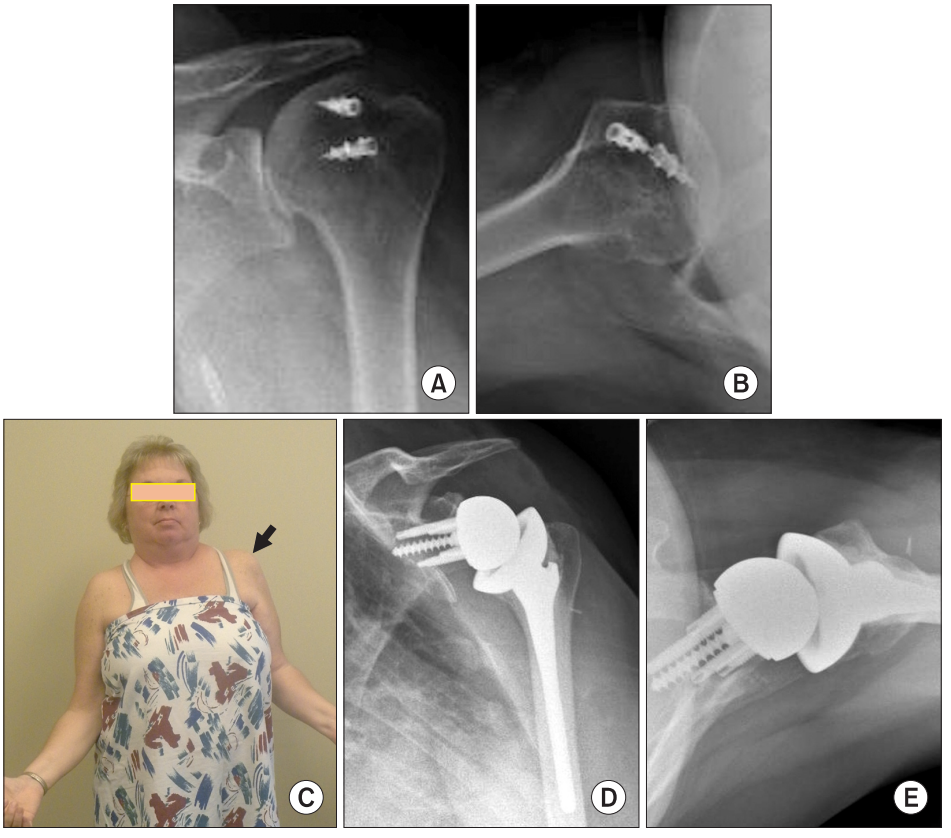

Fig. 8. A 47-year-old female patient with history of failed rotator cuff repair. (A) Preoperative conventional anteroposterior radiograph of the shoulder shows proximal migration of the humeral head. (B) Preoperative conventional axillary radiograph of the shoulder shows the humeral head has migrated anteriorly. (C) Deltoid atrophy (arrow) was evident in the preoperative physical examination. Conventional radiographs at 1 month follow-up show a well-fixed prosthesis: (D) anteroposterior view, and (E) axillary view.

report by De Wilde et al.,[19] with rTSA and latissimus dorsi transfer. Before surgery, one-third of the patient's anterior deltoid and the entire posterior deltoid were intact. A latissimus dorsi muscle transfer was performed to cover the middle and some anterior deltoid and to increase function. However, there is no direct evidence that a deltoid muscle without the middle head cannot elevate the arm, so the success of the use of a latissimus dorsi transfer and of an rTSA after this procedure remains in question. Tay and Collin[80] reported that a patient with irreparable spontaneous deltoid rupture combined with cuff tear arthropathy was successfully treated with rTSA alone without deltoid augmentation. In this patient, the only defect was to the middle deltoid muscle.

We have had several patients with varying degrees of deltoid muscle detachment or injury who also had extensive rotator cuff damage and shoulder arthritis. In patients with partial deltoid lesions, preoperative electromyography to understand the extent of the damage was helpful in planning the operation. Patients with an intact anterior deltoid were thought to be good candidates for this procedure despite the loss of other portions of the deltoid. When an rTSA is performed, the pain relief is often excellent, but patients have generally not experienced any substantial improvement in their motion (Fig. 8).

AGE AND REVERSE TOTAL SHOULDER ARTHROPLASTY (AGE LIMITATIONS OF THE REVERSE PROSTHESIS)

For several reasons, there are many precautions about the appropriate age for the use of an rTSA. First, the long-term results of rTSA are not known; the longest mean follow-up reported in the literature is 84 months. Second, Guery et al.[8] have shown some decrease function with a rTSA at a mean follow-up of 80 months after implantation. Although their data did not support any one age for which a reverse is contraindicated, they concluded that the rTSA should not be performed in patients under 70 years of age. Third, the long-term failure rate in some studies[8,33,75,81] has been worrisome. Favard et al.[81] have suggested that caution must be exercised when recommending rTSA, especially in younger patients, because they found that the Constant score and radiographic changes deteriorated with time, although the need for revision of rTSA was relatively low at 10 years. In a study about survivorship of rTSA, Guery et al.[8] reported a 10-year survival rate of 58%. However, the use of rTSA has expanded progressively to younger pa-

tients. Rittmeister and Kerschbaumer[76] reported 34-year-old patients with rheumatoid arthritis who were treated with rTSA, and Gallinet et al.[33] reported a 58-year-old patient with a proximal humeral fracture that was treated with rTSA.

CONCLUSIONS

The rTSA has proven to be a remarkable solution for patients with arthritis and a torn rotator cuff. Because of the good results in this patient population, the indications for the rTSA have expanded to include a wide variety of diagnoses and conditions. For many of these newer indications for surgery, the rTSA may provide excellent results, but there continue to be concerns about the long-term results and the complications of treatment in these populations. Additional study is necessary before the use of rTSA can be advocated in these different conditions.

CONFLICT OF INTEREST

Dr. McFarland is a consultant for Stryker Corporation for the shoulder arthroplasty division. None of the other authors have any conflicts of interest.

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