

Short-term of Reverse Total Shoulder Arthroplasty for the Treatment of Irreparable Massive Rotator Cuff Tear

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Background: To investigate the effectiveness of reverse total shoulder arthroplasty (RTSA) in treating irreparable massive rotator cuff tears (RCTs).

Methods: Twenty-nine patients who underwent RTSA for the treatment of irreparable massive RCTs and completed follow-up for at least 1 year were selected. Their mean age was 69.7 years (range, 59-80 years). The mean follow-up was 17.7 months (range, 12-42 months). The shoulder range of motion was measured preoperatively and at final follow-up. The functional result was evaluated using visual analog scale (VAS) for pain, American Shoulder and Elbow Surgeon (ASES) score, and Korean Shoulder Society (KSS) score. Additionally, the shoulders were categorized into two groups depending on prior history of surgery and the clinical outcomes were analyzed between two groups.

Results: Mean pain VAS improved, from 6.6 ± 1.2 to 2.7 ± 0.9 ($p=0.001$), and the mean functional VAS from 35.7 ± 4.2 to 73.3 ± 5.4 ($p=0.006$). The mean ASES score improved from 37.2 ± 2.8 to 75.0 ± 3.8 ($p=0.012$). The mean KSS improved from 36.5 ± 7.2 to 75.6 ± 5.4 ($p=0.009$), the mean forward elevation from 66.3 ± 4.7 to 135.6 ± 8.4 ($p=0.0001$), and the mean abduction from 45.2 ± 4.2 to 119.0 ± 6.5 ($p=0.0001$). Internal rotation differed significantly from the first sacral to the third lumbar vertebrae ($p=0.036$). External rotation did not change significantly ($p=0.076$). There was also no statistically significant difference between groups (no previous operation versus none). Four complications occurred: one superficial infection, one with anterior dislocation, one acromial fracture, and one clavicle fracture.

Conclusions: RTSA provides reliable pain relief and recovery of shoulder function in patients with massive irreparable RCTs in short-term follow-up.

(Clin Shoulder Elbow 2014;17(4):152-158)

Key Words: Rotator cuff; Massive; Arthropathy; Shoulder; Arthroplasty

Introduction

Massive irreparable rotator cuff tears may occur in cases of chronic tears with or without prior surgery. Treatments for irreparable rotator cuff tears include conservative treatments,¹ arthroscopic debridement, acromial decompression, and partial repair.^{2,3} Additionally, latissimus dorsi transfer^{4,5} and arthroplasty⁶⁻⁸ have shown variable results.

Although these methods can often provide pain relief, they

are not very reliable and often limited in achieving functional improvement. Hemiarthroplasty provides partial pain relief but poor functional results. Thus, it is typically only useful for elderly people with low motion demands. Total shoulder replacement has been shown to fail due to early glenoid loosening.⁹

To overcome these disadvantages, a reverse total shoulder arthroplasty has been used in place of conventional total shoulder arthroplasty in the treatment of massive rotator cuff tear. Since Grammont and Baulot¹⁰ first described the procedure, many

Received June 13, 2014. Revised August 26, 2014. Accepted September 14, 2014.

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Financial support: This paper was (partially) supported by the Chonbuk National University (CBNU) funds for overseas research. **Conflict of interests:** None.

studies have reported positive results with respect to pain relief and recovery of shoulder function.^{11,12)}

Given this background, we investigated the short-term follow-up outcome of reverse total shoulder arthroplasty for the treatment of irreparable massive rotator cuff tear.

Methods

Patients

From October 2008 to February 2011, we selected patients who had undergone reverse total shoulder arthroplasty to treat irreparable massive rotator cuff tear from two institutions. Among 36 patients who met the requirements, 29 (7 men, 22 women; mean age, 69.7 years; range, 59 to 80 years) who underwent at least 1 year of postoperative follow-up (mean, 17.7 months; range, 12 to 42 months) were analyzed. We used the Aequalis reverse type (Tornier, Montbonnot, France) in 20 cases and the Anatomical shoulder (Zimmer Inc., Warsaw, IN, USA) in 9 cases. Glenohumeral arthritis and active forward flexion $<90^\circ$ were observed in 26 cases. There was a case of glenohumeral arthritis with active forward flexion $>90^\circ$, and two cases without glenohumeral arthritis but a limited active forward flexion ($<90^\circ$).

The indications for surgery were cuff arthropathy, pseudoparalysis with a massive irreparable rotator cuff tear that involve two or more rotator cuff tendons with atrophy. Cuff tear arthropathy is characterized by rotator cuff dysfunction and end stage glenohumeral arthritis. Painful pseudoparesis is defined as active shoulder elevation of $<90^\circ$ in the presence of free passive anterior elevation. This assessment was based on a combination of findings on physical examination (rotator cuff muscle atrophy, dynamic instability, and limited range of motion) and radiographs (decreased joint space and abnormal joint position). The classification system described by Hamada et al.¹³⁾ was used to grade the preoperative radiographs.

The rotator cuff was considered to be irreparable if the rotator cuff was chronic massive rotator cuff tears that involve two or more rotator cuff tendons, severe pain for at least 6 months with weakness of rotator cuff muscle, an acromiohumeral interval of less than 6 mm on the true antero-posterior radiograph, fatty infiltration of the supraspinatus and infraspinatus muscles was greater than stage three according to the Goutallier classification,¹⁴⁾ and arthroscopic finding as retraction to glenoid of teared massive rotator cuff with poor tissue quality and non-mobilization.

The exclusion criteria were insufficient follow-up period (at least 1 years), severe deltoid impairment, preoperative infection history, revision surgery.

Clinical Assessment

In the clinical evaluation, shoulder range of motion was evaluated in terms of forward elevation, abduction, external rotation

at the side, and internal rotation preoperatively and at the final follow-up. The functional result was evaluated using a Visual Analog Scale (VAS) for pain and function, American Shoulder and Elbow Surgeon (ASES) score, and Korean Shoulder Society (KSS) score. Postoperative complications were also investigated.

Additionally, the shoulders were categorized in two groups depending on whether they had undergone surgery previously: 18 shoulders (Group A) had not undergone previous surgery, whereas 11 shoulders (Group B) had undergone at least one previous procedure.

In Group B, the mean duration to reverse total shoulder arthroplasty after previous surgery was 38.5 ± 20.5 months (range, 12 to 72 months). Five patients were performed with arthroscopic cuff repair, 2 with arthroscopic partial repair and 1 with mini-open repair. They all later complained of re-rupture with aggravating pain. For the other 3 patients, arthroscopic debridement was performed as rotator cuff suture was impossible; however, as they showed no clinical improvement, reverse total shoulder arthroplasty was performed.

The clinical outcomes in Groups A and B were analyzed and compared.

Surgical Technique and Rehabilitation

All procedures were performed in the beach-chair position using general anesthesia. The deltopectoral approach was used, and a portion of the pectoralis major insertion to aid in exposure was released. The subscapularis tendon was detached from the subscapularis footprint with tagging sutures. The joint capsule was released as much as possible towards the anatomical neck of the humerus. The glenohumeral joint was subjected to extension and external rotation to dislocate the head of the humerus. The humeral head resection was made with a retroversion angle between 0° and 20° according to the individual anatomy using a rotation guide with the forearm axis set to be neutral rotation. We made the osteotomy in 0° of retroversion for patients with teres minor muscle tears and a preoperative external rotation lag sign. After the head cutting, the glenoid baseplate fixation was followed according to the company instrumentation manual. We placed the guide for glenoid preparation inferiorly on the glenoid so that the base plate was fully supported by bone and flush with the inferior glenoid margin. We placed the guide wire in approximately 10° inferior tilt, because this position minimized the risk of scapular notching.¹¹⁾ Two anterior and posterior screws (4.5 mm) are positioned first to optimize compression of the baseplate with adequate cortical bone fixation. We placed two superior and inferior locking screws (4.5 mm) through the holes in the baseplate with bone purchase into the base of the coracoid and inferior scapular border. Then, we placed the central screw through the glenosphere and into the central hole of the baseplate. The polyethylene insert thickness was chosen based on soft-tissue tension during a trial reduction. In judging

the proper soft-tissue tension, our goal was minimal shucking (1 to 2 mm) with tension of the conjoined tendon, which was tight, but not enough to cause bowstringing of the tendon. Using bone cement, an actual humeral stem was inserted and combined with a polyethylene insert. The subscapularis tendon and joint capsule were reattached to the lesser tuberosity of humerus with No. 2 ethibond that was temporarily hooked.

Patients were placed in an abduction brace for 3 weeks, during which time only pendulum-type exercises were allowed. Passive range of motion exercises were initiated carefully 3 weeks after the surgery, beginning with forward flexion exercises. At 6 weeks after the surgery, active assisted exercises were performed. Active range of motion exercises and strength training exercises were started 12 weeks after the surgery.

Statistical Analysis

The Wilcoxon signed rank test was used to compare the preoperative and final follow-up results of VAS, active range of motion (forward flexion, abduction, external rotation, internal rotation), and shoulder function scores (ASES, KSS). The Mann-Whitney U test was used to analyze differences among the subgroups. The significance level was set at $p < 0.05$. All statistical analyses were conducted using the PASW Software ver. 18.0 (IBM Co., Armonk, NY, USA).

Results

Clinical Outcomes of the Entire Population (n=29)

The mean VAS score for pain improved, from 6.6 ± 1.2 preoperatively to 2.7 ± 0.9 at the final follow-up ($p=0.001$), while the mean VAS score for function improved, from 35.7 ± 4.2 to 73.3 ± 5.4 ($p=0.006$). The mean total ASES score for the entire population ($n=29$) improved, from 37.2 ± 2.8 to 75.0 ± 3.8 ($p=0.012$). The mean KSS improved, from 36.5 ± 7.2 to 75.6 ± 5.4 ($p=0.009$).

Shoulder motion also improved for all patients at the final follow-up. The mean forward elevation improved from $66.3 \pm 4.7^\circ$ to $135.6 \pm 8.4^\circ$ ($p=0.0001$) and the mean abduction improved from $45.2 \pm 4.2^\circ$ to $119.0 \pm 6.5^\circ$ ($p=0.0001$). Preoperative internal rotation was noted in one case at the lumbar 4 (L4) level, three cases at the L5 level, 18 cases at the sacrum 1 (S1) level, and seven cases at the coccyx level. At the final follow-up, internal rotations was noted in three cases at the L2 level, 16 cases at the L3 level, six cases at the L4 level, three cases at the L5 level, and one case at the S1 level. These preoperative and final follow-up differences in internal rotation were statistically significant ($p=0.036$). The mean external rotation improved from $35.5 \pm 2.7^\circ$ to $49.4 \pm 2.4^\circ$, but the difference was not statistically significant ($p=0.076$; Table 1).

Table 1. Clinical Outcomes in Total Population (n=29)

Variable	Preoperative	Last follow-up	p-value*
VAS for pain	6.6 ± 1.2	2.7 ± 0.9	0.001
VAS for function	35.7 ± 4.2	73.3 ± 5.4	0.006
ASES	37.2 ± 2.8	75.0 ± 3.8	0.012
KSS	36.5 ± 7.2	75.6 ± 5.4	0.009
Range of motion			
Forward elevation ($^\circ$)	66.3 ± 4.7	135.6 ± 8.4	0.0001
Abduction ($^\circ$)	45.2 ± 4.2	119.0 ± 6.5	0.0001
External rotation ($^\circ$)	35.5 ± 2.7	49.4 ± 2.4	0.076
Internal rotation ($^\circ$)	S1 (Coccyx-L4)	L3 (S1-L2)	0.036

Values are presented as mean \pm standard deviation.

VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons score, KSS: Korean Shoulder Society score, S: sacrum, L: lumbar.

*Wilcoxon signed rank test.

Clinical Outcomes in the No Previous Surgery (Group A; n=18) versus Failed Rotator Cuff Repair Group (Group B; n=11)

In Group A, the mean VAS for pain improved, from 6.3 ± 0.8 preoperatively to 2.1 ± 1.6 at the final follow-up, while the mean VAS score for function improved, from 36.4 ± 5.7 to 75.2 ± 3.6 . The mean total ASES score improved from 38.6 ± 3.8 to 76.4 ± 2.6 , while the mean KSS improved from 37.8 ± 6.8 to 77.1 ± 1.9 . In Group B, the mean VAS score for pain improved, from 7.1 ± 1.4 preoperatively to 3.8 ± 2.1 at final follow-up, whereas the mean VAS score for function improved from 34.8 ± 7.2 to 70.2 ± 4.6 . The mean total ASES score improved, from 34.8 ± 7.6 to 72.8 ± 1.0 , while the mean KSS improved, from 34.6 ± 8.2 to 73.1 ± 2.6 . Although Group A showed better overall outcomes than Group B, the difference was not statistically significant (Table 2).

With respect to the shoulder range of motion, the mean forward elevation improved, from $64.2 \pm 5.8^\circ$ to $138.7 \pm 10.8^\circ$, while the mean abduction improved, from $44.7 \pm 4.7^\circ$ to $121.4 \pm 7.3^\circ$. Preoperative internal rotation was noted in one case at the L4 level, two cases at the L5 level, 11 cases at the S1 level, and four cases at the coccyx level. At the final followup, the internal rotation had improved to two cases at the L2 level, 10 cases at the L3 level, four cases at the L4 level, one case at the L5 level, and one case at the S1 level. Additionally, the mean external rotation improved from $36.4 \pm 3.5^\circ$ to $50.3 \pm 1.7^\circ$.

In Group B, the mean forward flexion improved, from $69.7 \pm 7.2^\circ$ to $130.4 \pm 8.1^\circ$, whereas the mean abduction improved from $46.1 \pm 5.9^\circ$ to $115.1 \pm 10.3^\circ$. Preoperative internal rotation was noted in one case at the L5 level, seven cases at the S1 level, and three cases at the coccyx level. At the final follow-up, the internal rotation had improved to one case at the L2 level, six cases at the L3 level, two cases at the L4 level, and two

Table 2. Clinical Outcomes in Patient with No Previous Surgery (Group A) versus Those with Failed Rotator Cuff Repair (Group B)

	Group A		Group B		p-value*
	Preoperative	Last follow-up	Preoperative	Last follow-up	
VAS for pain	6.3 ± 0.8	2.1 ± 1.6	7.1 ± 1.4	3.8 ± 2.1	0.087
VAS for function	36.4 ± 5.7	75.2 ± 3.6	34.8 ± 7.2	70.2 ± 4.6	0.748
ASES	38.6 ± 3.8	76.4 ± 2.6	34.8 ± 7.6	72.8 ± 1.0	0.869
KSS	37.8 ± 6.8	77.1 ± 1.9	34.6 ± 8.2	73.1 ± 2.6	0.628
Range of motion					
Forward elevation (°)	64.2 ± 5.8	138.7 ± 10.8	69.7 ± 7.2	130.4 ± 8.1	0.081
Abduction (°)	44.7 ± 4.7	121.4 ± 7.3	46.1 ± 5.9	115.1 ± 10.3	0.162
External rotation (°)	36.4 ± 3.5	50.3 ± 1.7	34.1 ± 2.3	47.8 ± 3.4	0.764
Internal rotation	S1 (Coccyx–L4)	L3 (S1–L2)	S1 (Coccyx–L5)	L3 (L5–L3)	0.564

Values are presented as mean ± standard deviation. p-value: no previous surgery (Group A) versus failed rotator cuff repair (Group B). VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons score, KSS: Korean Shoulder Society score, S: sacrum, L: lumbar. *Mann-Whitney U test.



Fig. 1. (A) Preoperative antero-posterior radiograph of a 71-year-old female patient, showing superior migration of the humeral head, combined with glenohumeral arthritis due to an irreparable rotator cuff tear (Hamada type IV). (B) An antero-posterior radiograph at 7 months after surgery showing an acromial fracture. (C) An antero-posterior radiograph at the last follow-up showing union of a previous acromial fracture after K-wire and tension-band wiring.

cases at the L5 level. Additionally, the mean external rotation improved, from $34.1 \pm 2.3^\circ$ to $47.8 \pm 3.4^\circ$. While the shoulder range of motion in Group A was better than that in Group B, the difference was not statistically significantly (Table 2).

Complications

There were four cases of complications: one case was complicated with superficial infection, 1 with anterior dislocation, 1

with acromial fracture, and 1 with clavicle fracture. An anterior dislocation that was caused by a fall 3 months after the surgery did not recur after closed reduction. With respect to an acromial fracture that occurred 7 months after the surgery, K-wires and tension-band wiring were performed to achieve bone union (Fig. 1). Furthermore, conservative treatment of a clavicle fracture found 6 weeks after the surgery by radiography achieved bone union (Fig. 2).

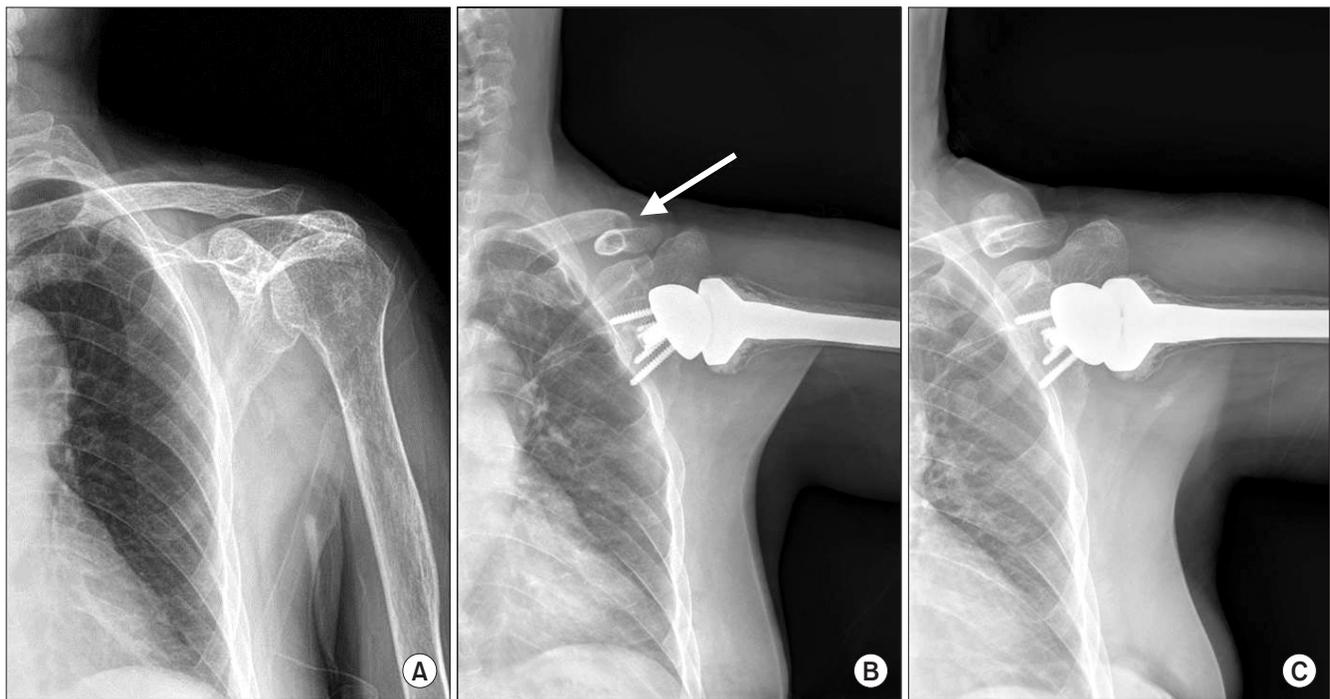


Fig. 2. (A) Preoperative antero-posterior radiograph of a 64-year-old woman, showing osteoarthritis and the superior migration of the left humeral head accompanied by the acetabularization of the acromion (Hamada type IV). (B) A radiograph at postoperative week 6 revealing displaced distal clavicle fracture (arrow). (C) A radiograph at postoperative month 8 showing fracture union.

Discussion

The reverse shoulder prosthesis was developed by Grammont and Baulot¹⁰ to restore shoulder function in case of a glenohumeral osteoarthritis associated with irreparable rotator cuff tear. The implant's design brings the center of rotation of the glenohumeral joint more medial and the insertion of the deltoid muscle more distally, which then increases the lever arm and the tension of the deltoid muscle. The reverse shoulder prosthesis can, thus, address both degenerative changes of the glenohumeral joint and a missing rotator cuff.^{11,12,15} Sirveaux et al.¹¹ reported 80 patients with a mean follow-up period of 3.6 years. The procedure was associated with good pain relief in 96% of the patients, and their Constant scores improved from 22 to 65 points. Frankle et al.¹² reported a minimum 2-year follow-up study of 60 shoulders with cuff-tear arthropathy. Reverse arthroplasty was associated with statistically significant improvements in pain and function, with a mean active elevation of approximately 105°. However, there was a 17% complication rate and a 12% rate of revision for implant failure.

In the present study, the short-term outcomes (mean, 17.7 months) after reverse total shoulder arthroplasty for the treatment of irreparable massive rotator cuff tear demonstrated a significant improvement in the VAS score, ASES score, and KSS at the final follow-up compared with the preoperative results. Furthermore, forward elevation, abduction, and internal rotation

also improved significantly at the final follow-up compared with the preoperative results. The reverse total shoulder arthroplasty is considered an effective treatment method that produces good clinical outcomes for irreparable massive rotator cuff tears accompanied by osteoarthritis and pseudoparalysis. However, while the mean external rotation improved, from 35° to 49° in our patients, the results did not show a statistically significant difference from the preoperative results. Simovitch et al.¹⁶ suggested that improvement in external rotation is uncommon after reverse shoulder arthroplasty, especially when there is fatty infiltration of the teres minor muscle. Werner et al.¹⁷ suggested that reverse total shoulder arthroplasty with a Grammont-type prosthesis can restore forward elevation and abduction but not external rotation, which should be explained as a limitation to patients prior to surgery. We believe that performing an osteotomy in zero retroversion to improve external rotation in patients with teres minor muscle tears and a preoperative external rotation lag sign has limitations. Because not all patients underwent magnetic resonance imaging, we believe that the preoperative severity of teres minor muscle tear and fatty infiltration were not fully evaluated.

In the absence of a functional teres minor muscle, some authors have proposed combining implantation of a reverse implant with transfer of the latissimus dorsi around the humeral shaft, through the same deltopectoral approach.¹⁸ Biomechanical studies suggest that latissimus dorsi muscle transfer improves

external rotation torque when combined with a reverse prosthesis, and that an insertion site on the posterior aspect of the greater tuberosity close to the teres minor muscle insertion produces a greater moment arm.¹⁹⁾ For patients with a severe external rotation lag and a torn teres minor muscle, this combined procedure may improve final external rotation, which seems to be associated with higher patient satisfaction.^{20,21)}

Some researchers have reported that the no previous shoulder surgery group exhibited significantly higher postoperative mean pain and function scores, according to the ASES system and Constant scores, than the previous shoulder surgery group.^{12,17)} However, in the present study, an analysis of clinical outcomes between the groups according to the presence or absence of a surgical history as cuff repair or debridement showed no statistically significant difference. However, in the present study, because 11 cases with a surgical history had undergone attempted mini-open, arthroscopic, or partial repair to treat a massive rotator cuff tear rather than a failed total shoulder arthroplasty or a revision replacement of hemiarthroplasty, a future comparative analysis of more cases is needed.

The reverse total shoulder arthroplasty is a complex procedure that changes joint physiology and biomechanics.²²⁾ As a result, the surgery may increase the potential for complications. Typical complications include scapular notching, baseplate failure, periprosthetic fractures, scapular fractures, infections, hematoma, instability, and nerve lesions.²³⁾

In the present study, there were four cases of complications: one case was complicated with superficial infection, 1 with anterior dislocation, 1 with acromial fracture, and 1 with clavicle fracture. We performed closed reduction for the anterior dislocation caused by a fall 3 months after surgery and required the patient to use an arm sling for 3 weeks; no recurrence was noted.

It is known that arm length is increased by approximately 2.5 cm in patients who undergo reverse total shoulder arthroplasty. This is also accompanied by increased tension of the deltoid muscle and increased loading on the origin of the deltoid muscle because of the medial movement of the center of rotation. This explains the possible occurrence of fracture at the origin of the deltoid muscle. It has been reported that acromial fractures occur in 1% to 7% of patients who undergo reverse shoulder arthroplasty.²⁴⁾ Crosby et al.²⁵⁾ reported that ipsilateral scapular fracture occurred during follow-up in 5.5% (22/400) of patients undergoing reverse total shoulder arthroplasty.

We diagnosed an acromial fracture that was sustained when the patient lifted a baggage in 7 months after a reverse total shoulder arthroplasty to treat a massive rotator cuff tear accompanied by arthritis. Bone union was achieved by performing K-wire and tension-band wiring. A 64-year-old woman with a painful massive left rotator cuff tear and glenohumeral arthritis

began to experience pain spontaneously at the anterior aspect of the shoulder at the distal clavicle when performing passive range of motion exercises after removing the abduction sling 3 weeks after the surgery. On radiography 6 weeks after surgery, a distal clavicle fracture was found. She was prescribed 3 additional weeks with the abduction sling and pendulum exercises, after which passive range of motion exercises were restarted carefully as conservative treatment. The patient achieved a complete bone union, as demonstrated on a radiograph at 8 months.

Our study has several limitations. First, it had a retrospective design and involved two institutions where different surgeons performed the same surgery. As such, patient selection and surgical techniques may have been biased.

In the present study, 2 different types of implant material were used. Reverse angle was not aligned during humeral head cutting. Furthermore, as the pre- and postoperative radiographic imaging techniques may have differed between the two institutions, radiographic analysis of events such as notching was excluded. Second, the number of subjects included was small and the minimum follow-up period of 12 months (mean, 17.7 months) was too short to determine implant longevity or evaluate the long-term implications of the radiographic findings.

Conclusion

Reverse shoulder arthroplasty provides reliable pain relief and recovery of shoulder function in patients with massive irreparable rotator cuff tear in a short follow-up period. Further long-term studies are needed to fully understand implant limitations and survivorship.

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