Glenoid Reconstruction in Revision Shoulder Arthroplasty

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Abstract Failed shoulder arthroplasty associated with glenoid bony deficiency is a difficult problem. Revision surgery is complex with unpredictable outcome. We asked whether revision shoulder arthroplasty with glenoid bone grafting could lead to good outcome. We retrospectively reviewed 21 patients who underwent glenoid bone grafting using corticocancellous bone grafting or impaction grafting using cancellous bone graft. Three patients underwent revision TSA, five patients hemiarthroplasty, 10 patients hemiarthroplasty with biologic resurfacing of the glenoid, and three patients revision to reverse TSA. The patients had minimum 25 months followup (average, 45 months; range, 25–92 months). All patients had improvement in their range of motion and the Constant-Murley score. Most improvement occurred in patients with glenoid

reimplantation. Patients who underwent revision reverse TSA had improvement in shoulder flexion but decrease in external rotation motion. We conclude revision shoulder arthroplasty with glenoid bone grafting can produce good short-term outcome and glenoid component reinsertion should be attempted whenever possible.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

The incidence and outcome of revision total shoulder arthroplasty have been infrequently reported in the literature [2, 3, 6, 8, 9]. The incidence of component revision using unconstrained Neer total shoulder arthroplasty has been reported between 0 and 13% with survivorship reported as 94.4% at 5 years and 71% at 11 years [2, 3, 6]. Cofield reported the Mayo Clinic experience with unconstrained total shoulder arthroplasty and determined the projected prosthetic survival to be 96% at 2 years, 92% at 5 years, and 88% at 10 years [8].

The etiologies of failed total shoulder arthroplasty and the need for revision surgery are multifactorial [2, 9]. Cofield and Edgerton reported 123 complications following 1183 shoulder arthroplasties [9]. The main reasons for failure are component wear, osseous deficiencies, soft-tissue deficiencies, and infection [2, 8, 9].

Component loosening and osseous deficiencies may occur on the humeral, glenoid or both sides. Glenoid component loosening has been recognized as one of the more common etiologies necessitating revision after total shoulder arthroplasty [4, 5, 9, 11, 17]. In addition, failure of humeral hemiarthroplasty secondary to glenoid erosion

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Each author certifies that his or her institution has approved the human protocol for this investigation, and that all investigations were conducted in conformity with ethical principles of research.

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necessitating revision has been well documented in the literature [7, 18]. Among the osseous deficiencies, insufficient bone stock on the glenoid side might be more critical and may complicate fixation, and without reconstruction, may be inadequate to support a new glenoid component. Glenoid reconstruction, whether to enhance stability or to create a framework to secure a glenoid component, can be technically challenging and, if inadequate, may lead to early revision failure.

We asked whether revision shoulder arthroplasty with glenoid reconstruction in patients with prior failed shoulder arthroplasty associated with glenoid deficiency would improve patient status in the short term.

Materials and Methods

We retrospectively reviewed the records of 21 patients who underwent revision TSA with reconstruction of glenoid bony deficiency between 1999 and 2004. There were 10 women and 11 men whose ages ranged from 36 to 77 years (mean, 61 years). The data collected on these patients were taken from the chart review in 14 patients and patient call-back in seven patients. The dominant extremity was involved in 13 patients. All patients had complete operative records and preoperative and postoperative evaluations. All patients underwent glenoid bone grafting with the use of corticocancellous bone allograft in those with peripheral or combined severe defects or with the use of impaction cancellous bone grafting in those with contained central defects. This study was approved by our institutional review board.

We performed revision TSA with placement of all cemented glenoid components in three patients (Table 1). Revision to hemiarthroplasty with glenoid bone grafting was performed in 15 patients (Tables 2, 3). In 10 of these 15 patients, we also performed biologic resurfacing (seven Achilles tendon allografts, three fascia lata autograft resurfacings) (Table 3). Three patients had revision to a reverse prosthesis (Table 4). The mean interval between TSA and revision surgery was 38 months (range, 7–92 months). No patient had a surgical procedure between the time of the TSA and the revision surgery. All patients had minimum 25 months followup (average, 45 months; range, 25–92 months).

The indications for revision surgery included a loose glenoid component in 14 patients with previous TSA, painful glenoid osteoarthritis in five patients with hemiarthroplasty and glenoid bone defect, an infected TSA with a cement spacer in one patient, and a massive rotator cuff tear in one patient with hemiarthroplasty.

We (MO, BE) classified glenoid bone deficiency according to Antuna et al. [1]. The location of the bone deficiency was classified as peripheral, central, or combined deficiency, and the level of deficiency was classified as mild, moderate, or severe. In this series, eight patients had severe central deficiency, four patients had severe peripheral deficiency, three patients had severe combined deficiency, five patients had moderate combined deficiency, and one patient had moderate central deficiency.

We performed augmentation of deficient glenoid bone stock with the use of a femoral head allograft in all patients. In patients with moderate central or combined bony deficiency, we reamed and impacted cancellous bone

Table 1. Revision total shoulder arthroplasty with glenoid bone grafting

Patient	Age/gender	Side (dominance)	Number of previous surgeries	Grade of glenoid defect	Constant-Murley score	
					Preoperative	Postoperative
1	56/M	Right	1-TSR	Severe-central	38	81
2	54/F	Left	1-TSR	Moderate-central	38	6
3	69/M	Left	1-TSR	Severe-central	33	76

Table 2. Revision to hemiarthroplasty with glenoid bone grafting

Patient	Age/gender	Side (dominance)	Number of previous surgeries	Grade of glenoid defect	Constant-Murley score	
					Preoperative	Postoperative
3	71/M	Left (ND)	1-TSR	Severe-central	24	80
4	36/M	Left (D)	1-TSR	Severe-combined	29	47
5	54/F	Left (D)	1-TSR	Severe-peripheral	43	92
6	56/M	Right (D)	1-HA	Severe-central	32	81
7	61/M	Right (D)	1-TSR	Severe-peripheral	31	80

D = dominant; ND = nondominant; HA = hemiarthroplasty.

Table 3. Revision to hemiarthroplasty with glenoid bone grafting and biologic resurfacing

Patient	Age/gender	Side (dominance)	Number of previous surgeries	Grade of glenoid defect	Type of biologic graft	Constant-Murley score	
						Preoperative	Postoperative
8	43/M	Right (D)	1-TSR	Severe-peripheral	Achilles' tendon allograft	36	52
9	55/M	Left (ND)	1-TSR	Severe-combined	Achilles' tendon allograft	34	76
11	66/F	Left (ND)	1-HA	Severe-combined	Fascia lata autograft	48	76
12	49/F	Right (D)	1-HA	Moderate-combined	Achilles' tendon allograft	36	76
13	48/F	Right (D)	1-TSR	Moderate-combined	Fascia lata autograft	24	79
14	49/M	Left (ND)	1-TSR	Moderate-combined	Fascia lata autograft	33	79
15	58/M	Right (ND)	1-TSR	Severe-central	Achilles' tendon allograft	27	81
16	46/F	Right (ND)	1-HA	Severe-central	Achilles' tendon allograft	23	52
17	43/F	Right (D)	1-TSR	Moderate-combined	Achilles' tendon allograft	27	52
18	53/M	Right (D)	1-TSR	Moderate-peripheral	Achilles' tendon allograft	31	54

D = dominant; ND = nondominant; HA = hemiarthroplasty.

Table 4. Revision to reverse shoulder prosthesis with glenoid bone grafting

Patient	Age/gender	Side (dominance)	Number of previous surgeries	Grade of glenoid defect	Constant-Murley score	
					Preoperative	Postoperative
19	77/F	Left (ND)	1-HA	Moderate-combined	28	92
20	50/F	Right (D)	1-TSR	Severe-central	29	83
21	56/F	Right (D)	1-TSR	Severe-central	25	84
			2-Removal of infected TSR and placement of antibiotic cement spacer			

D = dominant; ND = nondominant; HA = hemiarthroplasty.

Fig. 1A–B (A) An anteroposterior radiograph shows a patient with severe pain in the left shoulder 1 year after shoulder hemiarthroplasty secondary to glenoid arthritis and erosion. (B) A CT scan of the same patient shows moderate central and peripheral bony deficiencies of the glenoid.

graft from the femoral head. In patients with severe peripheral, central, and combined bony deficiency, bone grafting was performed with a portion of the femoral head sculpted to match the defect and fixed with corticocancellous screws (Figs. 1A–B, 2A–B, 3A–B). In 11 patients,

reimplantation of a new glenoid component was not possible because of severe glenoid bony deficiency. In 10 patients, we performed additional interposition arthroplasty with the use of an Achilles' tendon allograft (seven) and fascia lata autograft resurfacing (three) (Fig. 4A–C).

Fig. 2A–B (A) Anteroposterior and (B) axillary radiographs of the patient at 3 years followup show a well-integrated femoral bone allograft with well-positioned humeral and glenoid implants.

We (MO, BE) assessed the clinical outcome in all patients. Active elevation and external rotation were recorded pre- and postoperatively. We calculated Constant-Murley [10] scores in all patients. Nineteen of the 21 shoulders had complete radiographic followup. Glenohumeral subluxation was evaluated (MO, BE) with regard to the amount of translation and the direction of the humeral head relative to the center of the glenoid or glenoid component and documented as no subluxation, mild subluxation for 25% translation, moderate translation for 25%

to 50% translation, and severe for more than 50% translation. Lucency of the glenoid or humeral prosthesis or any displacement of the reverse glenoid component was also recorded.

Results

All patients had improved shoulder motion and Constant-Murley scores (Table 5). In the patients who underwent a revision TSA, the Constant-Murley score improved from an average of 32.3 to 68.6. In those who underwent revision hemiarthroplasty with no biologic resurfacing, the score improved from an average of 26.6 to 67.8, and in those who had revision hemiarthroplasty with biologic resurfacing, the score improved from an average of 28.5 to 60.6. Patients who underwent a revision to a reverse prosthesis had scores improve from an average of 23 to 72.

The improvement in range of motion, however, varied according to the group of patients. In patients who underwent revision TSA with placement of glenoid component, we noted improvement in forward flexion and external rotation. In patients who underwent a revision hemiarthroplasty with glenoid bone grafting we also observed improvement of external rotation but only modest improvement of forward flexion. In patients who underwent revision shoulder hemiarthroplasty with glenoid bone grafting and interposition of fascia lata or Achilles' tendon grafts, we found a modest improvement in forward flexion but no change in external rotation. Patients who underwent a conversion to a reverse prosthesis had improvement of forward flexion, but a decrease in external rotation.

Radiographic evaluation revealed a well-centered glenohumeral joint with no subluxation in 17 of 21 patients. CT scan was also obtained at 1 year in patients who underwent glenoid bone grafting with the use of cortico-cancellous allograft to evaluate the incorporation of the structural allograft. In the three patients who had a reverse prosthesis, the implant appeared well positioned and in good alignment. In one patient with hemiarthroplasty and biologic resurfacing, there was mild proximal subluxation of the humeral head. The radiographs of the same patient revealed moderate medialization of the humeral head as a result of partial bony graft resorption. There was no evidence of loosening in any humeral stem or the cemented glenoid component. The glenoid base plate in the reverse prostheses appeared well fixed with no evidence of displacement or osteolysis. We noticed mild scapular notching in two of these three shoulders but without apparent complications.

Two of the 21 patients with revision surgeries underwent additional surgery. One had the prosthesis extracted and an antibiotic cement spacer placed 4 months after

Fig. 3A–B (A) Axillary-lateral radiographs show the right shoulder with failed prior TSA, anterior humeral head subluxation, and severe glenoid central bony deficiency. (B) A CT scan of the right scapula

was performed after revision surgery with allograft bone grafting of a defective glenoid. Notice the contour, depth, and bony content of the glenoid appear restored.

Fig. 4A–C (A) Preoperative axillary radiograph of a patient shows glenoid component loosening with moderate central glenoid bony deficiency. (B) Intraoperative picture shows an Achilles' tendon allograft interposed to cover the glenoid defect, which has been

impacted with cancellous bone allograft. (C) Postoperative axillary radiograph shows the same patient after glenoid bone grafting, Achilles' tendon interposition, and revision humeral component replacement.

his revision surgery for management of infection (Fig. 5A–D). The second patient underwent first revision hemiarthroplasty with glenoid bone grafting for painful hemiarthroplasty associated with massive rotator cuff tear, but necessitated re-revision to a reverse TSA 13 months

postoperatively because of persistent symptoms. Both patients had improvement in their range of motion and Constant-Murley scores and were very satisfied with their surgeries at their last followup 25 months after their last surgeries.

Table 5. Average postoperative improvement in preoperative range of motion and constant scores

Variable	Revision TSA	Revision HA with glenoid bone grafting	Revision HA with glenoid bone grafting and interposition fascia lata of Achilles' tendon graft	Revision to reverse TSA
Forward flexion (FF)	70° (from average 46°–116°)	22° (from average 90°–112°)	23° (from average 77.5°–100.5°)	40° (from average 60°–100°)
External rotation (ER)	23° (3.3°–26.3°)	29° (from average 3.1°–32°)	No significant change (from average 34.3°–30°)	Decrease in ER 23° (from average 50°–27°)
Constant-Murley score	From 32.3 to 68.6	From 26.6 to 67.8	From 28.5 to 60.6	From 23 to 72

HA = hemiarthroplasty.

Fig. 5A–D (A) Anteroposterior radiograph of a patient who had an infection after revision TSA that necessitated extraction of implants and antibiotic cement spacer placement. (B) Anteroposterior radiographs show the same patient 6 months after incision and drainage and placement of an antibiotic cement spacer. Notice the displacement of the antibiotic cement spacer and the break at the base of the greater tuberosity by the plate from the spacer. (C–D) Anteroposterior

and axillary radiographs of the same patient performed 4 years after revision shoulder arthroplasty with the use of a reverse prosthesis and impaction bone grafting of the glenoid for central-contained bony deficiency. Notice the well-fixed glenoid hemisphere and mild bony overgrowth over the site of the previous greater tuberosity fracture. There is also apparent inferior scapular notching (white arrow) but without apparent consequence.

Discussion

The causes of failed shoulder arthroplasty have been well documented previously in the literature and include glenoid arthritis and glenoid component loosening as the most common causes of failure [4, 5, 7, 9, 11, 17, 18]. Glenoid component loosening is typically associated with pain [20]. Because of the small anatomic size of the bony glenoid, glenoid bony deficiencies frequently compromise component fixation and pose considerable reconstructive challenges. In many instances, the bony deficiency on the glenoid side could be complex and massive, which precludes placement of a glenoid component. We asked whether revision shoulder arthroplasty with glenoid reconstruction in patients with prior failed shoulder arthroplasty associated with glenoid deficiency would improve patient status in the short term.

As in most retrospective studies there are multiple limitations to this study. First, the number of reported patients is not sufficient to statistically determine clinically important differences in our outcomes between the various procedures. Second, the number of patients varies between the different groups of patients. We tried to present a complex problem and give an idea about the outcome of the available patients that we had with adequate followup. Third, in many of the presented patients, the followup is only 2 years. It will be more valuable to have a longer followup specifically because some of the patients are very active and younger in age, which indicates the higher chance of failure of their surgeries on longer followup. Finally, we had no control patients so it is difficult to draw conclusions as to whether our approaches would be superior to others.

Reconstruction of glenoid deficiency and placement of a glenoid component in patients with primary TSA has been successful with good outcomes [12, 19]. Neer and Morrison [12] reported 65 cases of 463 TSAs that underwent bone grafting of the glenoid to place a glenoid component. Twenty of these 65 cases were successfully treated with a large, internally fixed bone graft and 45 with smaller grafts in which they did not use internal fixation. Only two patients out of 463 were converted to hemiarthroplasty with grafting of the glenoid because of considerable lack of bone in the glenoid that made the placement of the glenoid component impossible. Nineteen of the 20 patients having large bone grafts were available for followup at an average of 4.4 years. The clinical results were considered excellent in 16, satisfactory in one, and the desired limited goals were obtained in two. At the final followup, none of the glenoid components had clinically migrated or loosened and no patient had further surgery. Steinmann and Cofield [19] reported 28 patients who underwent glenoid bone grafting for segmental glenoid wear during TSA. Humeral head autografts were used in 27 patients, and screw fixation

was used in 25 patients. At a minimum followup of 2 years (mean, 5.3 years; range, 2–11 years), 25 patients had no or slight pain and three patients had moderate pain. Using Neer's result rating, 13 shoulders were excellent, 10 satisfactory, and five unsatisfactory. When the radiographs were reviewed, 13 shoulders had no lucencies, 11 had incomplete lucencies, and four had complete lucencies. The authors concluded this technique of glenoid reconstruction to restore glenoid bone and joint alignment could lead to clinical and radiographic outcomes similar to TSA.

In revision TSA, placement of a glenoid component is not always possible after reconstruction of glenoid bony deficiency (Table 6). Neyton et al. [15] reported nine patients who underwent removal of loose glenoid components and reconstruction of the glenoid with corticocancellous bone grafting. At a minimum followup of 24 months five patients had satisfactory and four patients had unsatisfactory results according to Neer's criteria. Radiographs revealed central graft resorption with an average medialization of the humeral head within the glenoid of 4.1 mm (range, 1–11 mm). In a review from three French centers specializing in shoulder surgery [15] 19 patients underwent reimplantation of cemented glenoid components, 12 glenoplasty with or without bone grafting, five reverse TSA, and one resection arthroplasty for infection. At a minimum followup of 12 months the Constant-Murley score improved in all patients. Cemented glenoid reimplantation led to considerably improved function. Conversion to a reverse implant in patients with cuff tears led to improved pain scores. Neyton et al. [13] then reported nine patients who underwent, in one or two stages, glenoid bone grafting and implantation of a reverse TSA. The indications for this procedure included revision shoulder arthroplasty and cuff tear arthropathy. At a minimum followup of 24 months most patients were satisfied with their results mostly because of pain relief. Hawkins et al. [11] reported nine patients who underwent revision surgery for glenoid loosening. It was possible to reimplant seven of nine glenoid components. Antuna et al. [1] reported 48 shoulders that underwent glenoid component revision surgery. Eighteen shoulders underwent removal of the component and bone grafting for bone deficiencies, and 30 shoulders underwent implantation of a new glenoid component. At a minimum followup of 2 years there was considerable pain relief (86%) and improvement in range of motion in the group of patients who underwent revision of the glenoid component. The group of patients without a glenoid component was less satisfied than the group with glenoid reimplantation and pain relief was achieved in only 66%. Shoulder stability was achieved in 11 of the 17 patients who had instability preoperatively. Phipatanakul and Norris [16] reported 24 patients who underwent conversion of a TSA to humeral head replacement with

Table 6. Summary of study outcomes of revision shoulder arthroplasty with glenoid bone grafting

Study	Number of patients	Indications	Procedure	Mean followup (range)	Outcome
Neyton et al. [15]	9	Loose glenoid component and glenoid bone defect	Removal of glenoid component and reconstruction of the glenoid with corticocancellous bone grafting	30 months (24–39 months)	Five satisfactory, four unsatisfactory according to Neer criteria; central graft resorption averaging 4.1 mm (range, 1–11 mm)
Neyton et al. [14]	37	Failed TSA with glenoid bone defect	Reimplantation of glenoid component (19); glenoplasty with or without bone grafting (12); reverse TSA (5); resection arthroplasty (1)	18.5 months (12–69 months)	Constant-Murley score improved in all patients; conversion to a reverse TSA in cuff tears improved pain score; removal of glenoid component with bone grafting led to better outcome than simple removal of loose implant
Neyton et al. [13]	9	Failed TSA with glenoid defect and cuff tear arthropathy	Glenoid bone grafting and reverse TSA in one or two stages	24 months (24–41 months)	Most patients were satisfied; no graft failure; six patients with inferior scapular notching
Antuna et al. [1]	48	Glenoid failure (14); glenoid malposition leading to instability (5); glenoid loosening (29)	Removal of glenoid and bone grafting (18); reimplantation of new glenoid (30)	4.9 years (2–12 years)	Pain relief in 86% of patients with glenoid revision, 66% of patients with no glenoid reimplantation; stabilization of 11 of 17 patients who had preoperative instability
Phipatanakul and Norris [16]	24	Failed TSA with glenoid bone defect	Hemiarthroplasty with glenoid bone grafting	33 months (24–36 months)	75% with satisfactory pain relief; no significant improvement of range of motion; graft subsidence in 10 of 20 cases
Elhassan et al. (current study)	21	Failed shoulder arthroplasty with glenoid bone defect	Revision TSA with glenoid bone graft (3); hemiarthroplasty with glenoid bone grafting in five and additional biologic resurfacing in 10; revision to reverse TSA with glenoid bone graft (3)	25 months (25–92 months)	Improvement in Constant-Murley score in all patients; significant improvement in those with glenoid reimplantation; improved flexion and decreased external rotation in the patients with revision to reverse TSA

glenoid bone grafting for glenoid bony deficiency resulting from component loosening and osteolysis. Eighteen of the 24 patients (75%) had satisfactory pain relief at a minimum followup of 24 months. Graft subsidence was observed in 10 of 20 cases.

All our patients had improvement of their Constant-Murley scores after revision shoulder arthroplasty with glenoid reconstruction. Considerable improvement in range of motion was seen in patients who had reimplantation of the glenoid component. Improvement in range of motion, in particular shoulder external rotation, was also more considerable in patients who underwent revision hemiarthroplasty with glenoid reconstruction without biologic resurfacing compared with the patients who underwent biologic resurfacing. Patients who underwent revision to a reverse prosthesis had considerable improvement in their Constant-Murley score and active forward flexion. However, these patients had considerable loss of external rotation after the revision surgery. This loss of external rotation could be explained by the loss of the remnant of the greater tuberosity, which holds the attachment of infraspinatus and teres minor during the time of the revision surgery. The senior authors (LDH, JPW) currently perform concurrent latissimus dorsi and teres major transfer during primary or revision reverse prosthesis in patients who have considerable weakness or loss of external rotation. The preliminary outcome of this procedure is promising.

Reconstruction of glenoid bony deficiency during revision shoulder arthroplasty is a challenging problem. We believe the surgeon should attempt to reimplant the glenoid component if possible because of a better anticipated outcome. Otherwise, bone grafting without glenoid reimplantation could lead to a fair or good outcome. In patients with failed TSA or hemiarthroplasty, and loss of their rotator cuff, then revision with a reverse prosthesis, with or without latissimus/teres major transfer, remains an option that might lead to a good outcome.

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