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Shoulder arthroplasty for sequelae of poliomyelitis

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Background: Polio infection can often lead to orthopedic complications such as arthritis, osteoporosis, muscle weakness, skeletal deformation, and chronic instability of the joints. The purpose of this study was to assess the outcomes and associated complications of arthroplasty in shoulders with sequelae of poliomyelitis.

Methods: Seven patients (average age, 70 years) were treated between 1976 and 2013 with shoulder arthroplasty for the sequelae of polio. One patient underwent reverse shoulder arthroplasty, 2 had a hemiarthroplasty, and 4 had total shoulder arthroplasty. Average follow-up was 87 months. Outcome measures included pain, range of motion, and postoperative modified Neer ratings.

Results: Overall pain scores improved from 5 to 1.6 points (on a 5-point scale) after shoulder arthroplasty. Six shoulders had no or mild pain at latest follow-up, and 6 shoulders rated the result as much better or better. Mean shoulder elevation improved from 72° to 129°, and external rotation improved from 11° to 56°. Average strength in elevation decreased from 3.9 to 3.4 postoperatively, and external rotation strength decreased from 3.9 to 3.3. This, however, did not reach significance. Evidence of muscle imbalance with radiographic instability was found in 4 shoulders that demonstrated superior subluxation, anterior subluxation, or both. This remained asymptomatic. No shoulder required revision or reoperation.

Conclusions: Shoulder arthroplasty provides significant pain relief and improved motion in patients with sequelae of poliomyelitis. Muscle weakness may be responsible for postoperative instability, and careful selection of the patient with good upper extremity muscles must be made.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Shoulder arthroplasty; poliomyelitis

Before 1974, poliovirus was responsible for 500,000 new cases of palsy per year worldwide. Polio has been eradicated from the American continent since 1994; however, the disease remains active on the African and Asian continents and provides a reservoir for reintroduction of polio into polio-free countries.[13] Moreover, the last outbreak in the United States was in the early 1950s, before effective vaccines were available in the mid to late 1950s.[7] Those experiencing the last wave of this disease are now in the age group in which arthroplasty is commonly considered. Therefore, orthopedic surgeons may be confronted with the management of the later sequelae of the disease.[7,8] Paralysis occurs in one case out of

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Table I Patient and disease characteristics

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7
Year of polio diagnosis	—	1948	1940	1945	1932	—	1952
Year of surgery	1996	2010	2000	2009	2003	1994	2011
Age at surgery	74	78	60	79	78	60	68
Gender	M	M	F	F	M	F	F
Strength							
Elevation	4	4	4	4	5	3	3
ER	4	4	4	4	5	3	3
Elbow and hand weakness	Moderate	Mild	Moderate	None	Mild	None	None
Lower extremity involvement	Cane	None	Wheelchair	Wheelchair	Wheelchair	Crutches	Wheelchair
Glenohumeral instability	—	No	Yes	No	Yes	Yes	Yes
Direction	—	Anterior	Superior	—	Anterior	Anterior	Superior
Degree	—	Mild	Moderate	—	Mild	Moderate	Severe
Growth disturbance	No	No	No	No	No	No	No
Contracture	No	No	Yes	No	No	No	No
Osteoporosis	No	Yes	Yes	Yes	No	No	No
Active motion							
Elevation	65	90	70	60	90	40	20
ER	0	20	20	10	0	10	20
IR	L5	Posterior ileum	Abdomen	Sacrum	L4	L5	Sacrum
Cartilage loss	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bone deformity	No	No	No	No	No	No	No
Rotator cuff	Normal	Thin	Thin	Normal	Torn	Normal	Torn
Procedure	TSA	TSA	TSA	TSA	HA	HA	RSA

ER, external rotation; *IR*, internal rotation; *TSA*, total shoulder arthroplasty; *HA*, hemiarthroplasty; *RSA*, reverse shoulder arthroplasty.

100 to 1000 infections[7,11] and can lead to orthopedic complications such as arthritis, osteoporosis, muscle weakness, skeletal deformation, and chronic instability of the joints.[7] Lower limbs are more frequently affected. The literature on surgical treatment of shoulder arthropathy secondary to poliomyelitis remains limited. The purpose of this study was to evaluate the clinical outcomes and complications of shoulder arthroplasty in patients with sequelae of poliomyelitis.

Materials and methods

All affected patients were identified through our institution's arthroplasty database, which has enrolled all joint replacements performed since 1969. We identified 8 patients (3 men, 5 women) who underwent shoulder arthroplasty for the sequelae of poliomyelitis between 1994 and 2013. One patient had <2 years of follow-up and was excluded from the analysis. Four shoulders were treated with total shoulder arthroplasties (Cofield 2; Smith & Nephew, Memphis, TN, USA) and 2 with hemiarthroplasties (Cofield 2) for osteoarthritis, and 1 shoulder was treated with a reverse shoulder arthroplasty (Comprehensive; Biomet, Warsaw, IN, USA) for cuff tear arthropathy. All patients had upper extremity weakness but maintained at least antigravity strength in elevation and external rotation on the affected shoulder. Two patients required gait aids and 4 were wheelchair bound. All patient charts, including preoperative orthopedic and neurologic examinations, operative reports, and clinical follow-up, were reviewed. Patients were asked to return for clinical and radiographic evaluation at regular follow-up intervals. Those who were unable to return for evaluation were sent a validated shoulder questionnaire to evaluate their function and satisfaction.[4] Patient and disease characteristics are detailed in Table I.

Surgical technique

All arthroplasties were performed through a standard deltopectoral approach. The rotator cuff was visually inspected. Two patients were found to have a thin rotator cuff, and 2 had a rotator cuff tear (1 of them underwent reverse shoulder arthroplasty, and the other underwent hemiarthroplasty with a side-to-side repair of the supraspinatus and the anterior portion of the infraspinatus). The subscapularis was tenotomized in 4 cases and released from the humerus in 3. Two patients required concurrent capsular release (1 inferior and 1 posterior). All stems were uncemented with a mean retroversion of 35° (range, 30°-45°).

Patients were placed in a sling with passive motion exercises during the first 6 weeks, and then active range of motion exercises and isometric strengthening were begun. The patients with lower limb weakness were transferred to a nursing home and were not authorized to have weight-bearing activities with the arm until the end of the third month.

Clinical evaluation

At our institution, all patients who have undergone shoulder surgery have been prospectively observed since 1969.[1] Patients

are brought back at routine intervals for assessments. Pain, function, and physical findings are obtained at routine intervals. Patients may return for clinical visits or be contacted by letter questionnaire or telephone interview per our joint registry protocol.[14] Pain is graded on a 5-point scale.[6,12] A score of 1 indicates no pain; 2, slight pain; 3, pain after unusual activity; 4, moderate pain; and 5, severe pain. Active elevation and external rotation were recorded in degrees. Internal rotation was assessed by the most cephalad vertebral segment reached by the thumb. Muscle strength was assessed using a modified Medical Research Council scale whereby full motion in the rating was the full range of passive motion: 0 corresponds to no contraction; 1, visible or palpable contraction but no motion; 2, full range of motion when gravity is eliminated; 3, full range of motion against gravity; 4, full range of motion against gravity and moderate resistance; and 5, full range of motion against full resistance.[10] Shoulders were assessed using the modified Neer rating system.[4,12] An excellent result is assigned to shoulders with no or slight pain, external rotation $\geq$45°, elevation $\geq$140°, and patient-reported satisfaction. A satisfactory result is assigned for no or slight to moderate pain only after vigorous activity, external rotation $\geq$20°, elevation $\geq$90°, and patient-reported satisfaction. Any reoperation or failure to meet these criteria resulted in an unsatisfactory rating. Subjective satisfaction was determined by asking the patients to compare the shoulder with before surgery and to assign a rating of much better (1), better (2), the same (3), or worse (4).

Radiographic evaluation

Preoperative, initial postoperative, and most recent radiographs for each shoulder were reviewed. Three projections were used for radiographic analysis: anteroposterior, internal and external rotation, and axillary. Radiographs for patients who underwent total shoulder arthroplasty were reviewed to determine the presence of glenohumeral subluxation, periprosthetic lucency, and component shift in position. Radiographs for patients who underwent hemiarthroplasty were reviewed to determine glenohumeral subluxation, periprosthetic lucency, component shift in position, and glenoid erosion. Glenohumeral subluxation was assessed as the percentage of humeral head translation relative to the glenoid. Subluxation was graded as none, mild (<25% translation), moderate (25%-50% translation), or severe (>50% translation). Periprosthetic lucencies were defined as grade 0, no radiolucent line; grade 1, incomplete 1-mm line; grade 2, complete 1-mm line; grade 3, incomplete 1.5-mm line; grade 4, complete 1.5-mm line; and grade 5, 2-mm-wide lucent line and complete.[16]

Preoperative glenoid morphology was assessed when possible according to the method of Walch et al,[18] in which type A corresponds to a well-centered humeral head with symmetric erosion, type B corresponds to an exaggerated posterior wear pattern with posterior subluxation of the humeral head, and type C corresponds to glenoid retroversion of >25° regardless of erosion. Among patients receiving shoulder total arthroplasty, 1 glenoid was graded as A1 and 3 as A2. One shoulder did not have adequate preoperative radiographs for review. Of those undergoing hemiarthroplasty, 1 patient had an A2 glenoid and did not have adequate radiographs for evaluation. The patient treated by reverse shoulder arthroplasty had a type A1 glenoid.

Statistical analysis

Descriptive statistics are detailed as mean (standard deviation) for continuous measures and number (percentage) for discrete variables. A paired t test was used to compare preoperative vs. postoperative changes. The α level for all tests was set at .05 for statistical significance.

Results

Clinical outcome

The mean age at the time of surgery was 70 years (range, 60-79 years), with an average follow-up of 87 months (range, 24-186 months) (Table II). None of the shoulders required revision or reoperation, and no complications were found. Preoperatively, all patients reported severe pain (average preoperative pain score was 5). Pain reduction was achieved in all 7 shoulders ($P < .001$), with pain scores averaging 1.6 (range, 1-3) at follow-up. Seven of the 8 shoulders had no pain or mild pain at latest follow-up. Similarly, range of motion was also improved. Elevation and external rotation improved significantly, respectively, from 72° (range, 20°-90°) preoperatively to 129° (range, 70°-180°) postoperatively ($P < .05$) and from 11° (range, 0°-20°) preoperatively to 56° (range, 10°-90°) postoperatively ($P < .01$). Internal rotation was increased in 4 patients, unchanged in 1, and decreased in 2. Internal rotation remained unchanged at L5 postoperatively ($P = .36$). According to modified Neer ratings, 2 patients (1 total shoulder arthroplasty and 1 hemiarthroplasty) had unsatisfactory results because of insufficient range of motion. There were a total of 3 excellent and 2 satisfactory results based on these ratings. Subjectively, 6 of the 7 shoulders rated the result much better or better. Average strength decreased from 3.9 (range, 3-5) preoperatively to 3.4 (range, 3-4) postoperatively in elevation and from 3.9 (range, 3-5) preoperatively to 3.3 (range, 3-4) postoperatively in external rotation. This, however, did not reach significance ($P = .22$ and $P = .10$ respectively).

Radiologic outcome

Three patients did not have radiographs after the 1-year postoperative mark and were eliminated from radiographic evaluation. The remaining 4 shoulders were evaluated at an average of 77 months (range, 12-208 months) postoperatively. Radiographic instability was identified in 4 patients who demonstrated superior glenohumeral subluxation, anterior subluxation, or both. This, however, remained asymptomatic. At last follow-up, 1 patient was found to have an incomplete 1.5-mm line, and 1 had an incomplete 1-mm line around the glenoid component. No radiolucent lines were observed around the glenoid in the

Table II Results

Variable	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Average
Pain								
Preoperative	5	5	5	5	5	5	5	5
Postoperative	2	2	3	1	1	1	1	1.6
Change	3	3	2	4	4	4	4	3.4
P value	—	—	—	—	—	—	—	**< .001**
Motion								
Active elevation								
Postoperative	70	130	90	180	180	80	170	128.6
Change	5	40	20	120	90	40	80	56.4
P value	—	—	—	—	—	—	—	**< .05**
ER								
Postoperative	10	40	30	90	90	50	80	55.7
Change	10	20	10	80	90	40	60	44.3
P value	—	—	—	—	—	—	—	**< .01**
IR								
Postoperative	Trochanter	L5	Cannot reach abdomen	T9	L1	L5	L3	L5
Change	−4	2	−1	9	3	0	4	1.9
P value	—	—	—	—	—	—	—	.36
Strength								
Active elevation								
Postoperative	4	4	4	3	3	3	3	3.4
Change	0	0	0	−1	−2	0	0	−0.4
P value	—	—	—	—	—	—	—	.22
ER								
Postoperative	3	4	4	3	3	3	3	3.3
Change	−1	0	0	−1	−2	0	0	−0.6
P value	—	—	—	—	—	—	—	.10
Glenohumeral instability	Yes	No	Yes	—	Yes	Yes	No	—
Direction	Superior	—	Anterosuperior	—	Anterior	Anterior	—	—
Degree	Moderate	—	Severe	—	Moderate	Mild	—	—
Neer rating	Unsatisfactory	Satisfactory	Satisfactory	Excellent	Excellent	Unsatisfactory	Excellent	

ER, external rotation; *IR*, internal rotation.

other patients, and no signs of loosening were found around the humerus.

Discussion

Shoulder replacement in patients with sequelae of poliovirus and postpolio syndrome is challenging for several reasons. First, all patients have variable degrees of shoulder muscle weakness, which can lead to chronic joint instability and subsequent postoperative instability.[15] Postoperative instability has indeed been the main concern in this population after total hip[19,20] and knee[5,9] arthroplasty. In our series, we did not find any case of postoperative dislocation, but radiographic instability was observed in 4 cases with either anterior or superior glenohumeral subluxation (Figs. 1 and 2).

Second, these patients often have lower extremity paralysis or weakness and therefore rely heavily on their upper limbs for activities of daily living. They often require assistive devices, such as canes or wheelchairs, and use their arms to help themselves transfer or even use the shoulders as weight-bearing joints. This could theoretically lead to early mechanical complications, such as implant loosening or polyethylene wear in total shoulder arthroplasty and glenoid erosion in hemiarthroplasty, but again, this was not observed in our series. This is consistent with the findings in the study of Hattrup and Cofield,[7] in which no failure from radiographic loosening was observed in a population of 6 paraplegic patients treated by shoulder arthroplasty. The lack of muscle strength or weakness of the rotator cuff and deltoid could explain the lack of erosion, loosening, and possibly pain we observed in our series.

The average age at the time of surgery in our population (70 years) is higher than the age reported in other joint replacements in similar populations (range, 48-65 years)[2,5,9,17,20] but comparable to the only case reported of shoulder replacement in a patient with sequelae of poliomyelitis (73 years).[3] This may indicate that shoulder symptoms do not develop until later in these patients. More

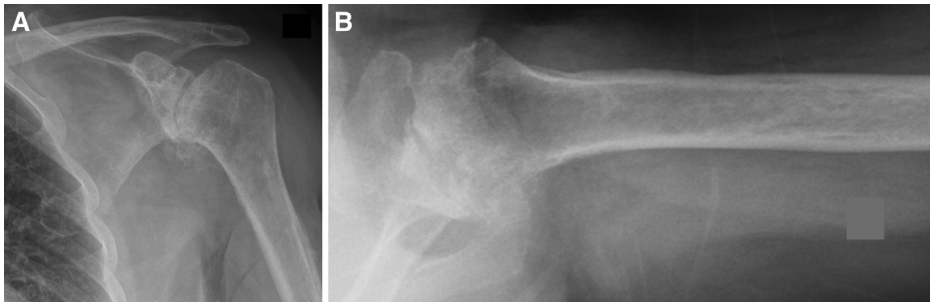

Figure 1 Preoperative anteroposterior (**A**) and axillary (**B**) views of a left shoulder (patient 3) reveal flattening of the humeral head, A2 glenoid erosion, cartilage loss, and osteophytes. The humeral head appears to have mild anterior subluxation.

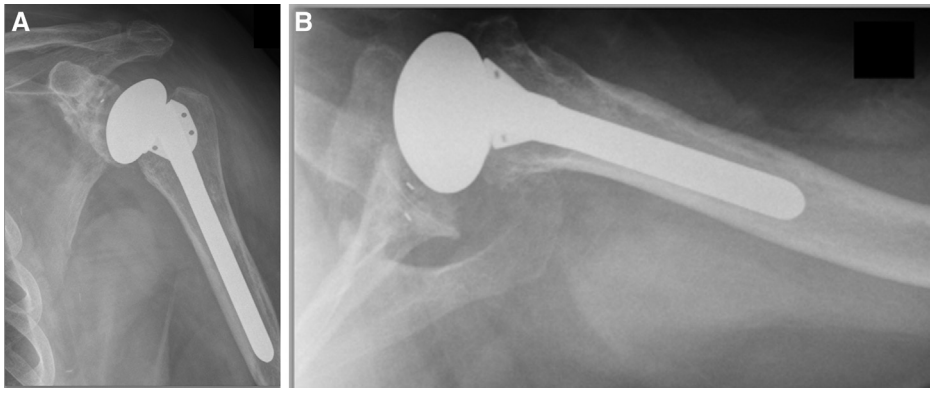

Figure 2 Anteroposterior (**A**) and axillary (**B**) views of a left shoulder (patient 3) at last follow-up (121 months postoperatively) reveal anterior subluxation of the humerus.

likely, these patients may attempt to delay surgery as they are often dependent on their upper extremities for weight bearing.

All the patients in our series had greater than antigravity strength in elevation and external rotation, meaning that they had good upper extremity muscles and that they were able to maintain their muscle strength over time despite significant fatty replacement of most of their shoulder muscles (Fig. 3).

The literature assessing shoulder arthroplasty in the postpoliomyelitis population is limited.[3] Joint replacements of the knee and the hip, however, have been more widely reported and are known to provide pain relief and improved range of motion.[2,5,9,17,20] Our series demonstrated similar results in the shoulder with satisfactory survivorship and no complications.

The main limitations of our study include its retrospective type, which entails in it all the limitations of a retrospective study, and the small number of patients. This limitation was unavoidable because of the rarity of poliomyelitis and the low number of patients with poliomyelitis undergoing shoulder replacement. This makes it difficult to draw general conclusions; however, it provides the largest series of shoulder arthroplasties performed for the sequelae of poliomyelitis and may aid in counseling of future patients.

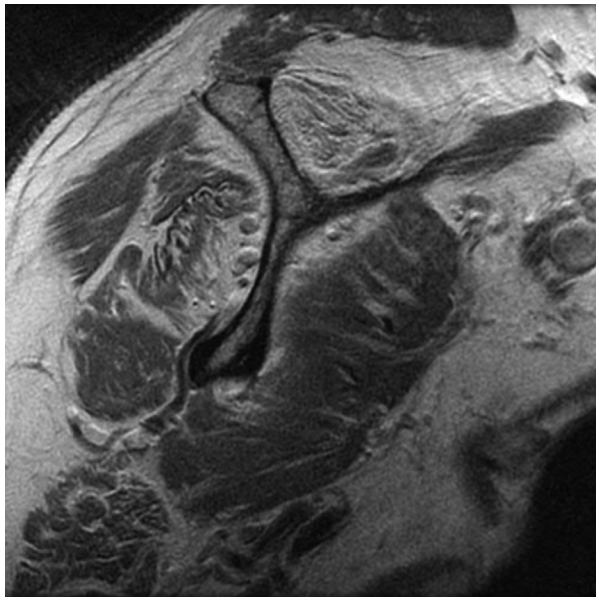

Figure 3 Preoperative coronal magnetic resonance image of the right shoulder (patient 5) shows marked fatty infiltration of the supraspinatus and infraspinatus muscles that were not torn. At last follow-up, this patient was found to have moderate anterior subluxation of his humeral head.

Conclusion

Shoulder arthroplasty provides pain relief and improved range of motion in patients with sequelae of poliomyelitis despite important fatty infiltration in their muscles around the shoulder. However, muscle weakness may be responsible for postoperative instability, and careful selection of the patient with good upper extremity muscles must be made.

Disclaimer

Robert Cofield receives royalties for shoulder prosthesis design from Smith-Nephew.

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