SCIENTIFIC ARTICLE

Shoulder Arthroplasty for Sequelae of Obstetrical Brachial Plexus Injury

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Purpose Shoulder arthroplasty following obstetrical brachial plexus injury (OBPI) is technically challenging because glenoid morphology, muscle balance, and humeral version are substantially altered compared with the neurologically intact shoulder. The purpose of this study is to report the outcome of shoulder arthroplasty in a group of patients with end-stage arthritis secondary to OBPI.

Materials and methods Seven patients with OBPI and secondary glenohumeral arthritis were treated with shoulder arthroplasty between 1976 and 2014. Two underwent hemiarthroplasty (HA), 2 underwent total shoulder arthroplasty (TSA), and 3 underwent reverse shoulder arthroplasty (RSA). One HA was lost to follow-up and was excluded. The remaining 6 patients (mean age, 62.5 years old at the time of surgery) were followed for a minimum of 2 years (mean, 7.5 years; range, 2−13 years) Outcome measures included pain, range of motion, and postoperative modified Neer ratings.

Results Pain improved in all shoulders. Mean forward flexion was unchanged. No shoulders treated with HA/TSA regained forward elevation above 90°, compared with 1 out of the 3 RSAs. External rotation improved from a mean of −10° to 20°. Active internal rotation decreased from L1 to L5. Immediate postoperative radiographs showed either severe posterior or posterosuperior subluxation in all 3 patients treated with nonconstrained implants.

Conclusions Shoulder arthroplasty is an acceptable option to relieve pain in patients with symptomatic shoulder arthritis as a sequel of OBPI. However, range of motion improvements are not expected. *(J Hand Surg Am. 2018;■(■):1.e1-e7. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study /level of evidence Therapeutic V.

Key words Shoulder arthroplasty, Erb palsy, obstetrical brachial plexus injury, glenoid dysplasia, humeral dysplasia.

Online Exclusive

OBSTETRIC BRACHIAL PLEXUS INJURY (OBPI) occurs in 0.3 to 4 per 1000 live births in developed countries.[1−5] Most patients experience full nerve recovery in the first few months of life and develop full upper extremity function without sequalae.[6] However, patients with incomplete nerve recovery may experience variable degrees of shoulder and upper extremity dysfunction. This commonly

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Received for publication September 19, 2017; accepted in revised form February 5, 2018.

M. Frankle receives royalties from DJO Surgical, Austin, TX, for prosthetic design and consulting payments from DJO Surgical, Cayenne Medical, Scottsdale, AZ, and Synchrony Healthcare Communications, West Chester, PA. R. Cofield receives royalties for shoulder prosthesis design from Smith and Nephew, Memphis, TN. The rest of the authors declare that they have no relevant conflicts of interest.

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0363-5023/18/■ ■-0001$36.00/0
https://doi.org/10.1016/j.jhsa.2018.02.006

includes internal rotation contractures of the shoulder with progressive posterior subluxation. This, in turn, results in significant distortion of the anatomy around the shoulder joint, including a retroverted and dysplastic glenoid, epiphysiolysis of the humeral head, downsloping of the acromion, and an elongated, lateralized coracoid. The presence of glenoid dysplasia has previously been associated with progressive degenerative arthritis[7] and arthropathy of the shoulder in patients with OBPI, as a result of glenohumeral joint dysplasia. This is more complicated in patients with OBPI because residual paralysis may lead to a significant imbalance of the forces around the severely dysplastic glenohumeral joint.

The combination of soft tissue contractures, muscular imbalance, and bone deformities poses significant challenges when shoulder arthroplasty is considered as treatment for arthritis in patients with this uncommon shoulder deformity. The purpose of this study is to report the outcome of shoulder arthroplasty in a small group of patients with OBPI who underwent the procedure for end-stage shoulder arthritis.

MATERIALS AND METHODS

Following institutional review board approval, the total joint registry database from 2 institutions was reviewed for patients with OBPI who had undergone shoulder arthroplasty between 1976 and 2014. All patients undergoing arthroplasty had failed nonsurgical management including activity modification, over-the-counter analgesics, and periodic corticosteroid injections. Our database did not allow us to capture the number of patients treated with nonarthroplasty procedures or those treated nonsurgically. Seven patients were identified: 2 hemiarthroplasties (HAs), 2 total shoulder arthroplasties (TSAs), and 3 reverse shoulder arthroplasties (RSAs). All HAs and TSAs were performed prior to the introduction of the RSA in 2004. One HA was lost to follow-up and was excluded from the study. The remaining 6 patients (four men: mean age, 60.5 years old at the time of surgery; and 2 women: mean age, 66.5 years old at the time of surgery) with a minimum follow-up of 2 years were included in this study. A detailed review of the medical records, surgeon's clinical notes, and operative reports was performed. The 6 patients were followed at routine intervals for examination and radiographic evaluation.

Clinical evaluation

At the time of last follow-up, pain was graded using the visual analog scale (VAS). Patients were asked to rate their average daily pain using the VAS pain scale, with 0 representing no pain and 10 representing their worst imaginable pain. Active elevation and external rotation were recorded in degrees. Internal rotation was determined by the highest vertebral segment that could be reached by the thumb.

Radiographic evaluation

Preoperative, initial postoperative, and most recent radiographs were reviewed. Three projections were used for radiographic analysis: anteroposterior, with the arm in internal and external rotation, and an axillary radiograph. These were used before surgery to evaluate the extent of dysplastic changes associated with glenohumeral subluxation. Glenoid dysplasia was assessed using the Walch classification,[7] and glenoid retroversion was evaluated using the radiographic classification of glenohumeral dysplasia described by Waters et al.[8] Posterior glenohumeral joint subluxation was assessed by measuring the distance from a bisecting scapular line to the anterior portion of the humeral head, divided by the circumference of the head, multiplied by 100 as described by Waters et al.[8]

After surgery, the same views were used to evaluate glenohumeral joint subluxation, periprosthetic lucency, and component shift in position. Postoperative glenohumeral subluxation was assessed as a percentage of humeral head translation on the glenoid as follows: none; mild ($<$ 25% translation); moderate (25%−50% translation); and severe ($>$ 50% translation).

Periprosthetic radiolucency was defined with 6 grades (0-5): grade 0, no radiolucent line; grade 1, incomplete and $\leq$1-mm line; grade 2, complete and $\leq$1 mm line; grade 3, incomplete and $\leq$1.5-mm line; grade 4, complete and $\leq$1.5-mm line; and grade 5, complete and $\geq$2-mm line.[9]

Surgical technique

Two patients underwent anatomical TSAs using the Cofield system (Smith and Nephew, Memphis, TN) using an all-polyethylene cemented glenoid component and uncemented ingrowth humeral component. One patient underwent HA using a Cofield 2 uncemented humeral stem (Smith and Nephew) and the 3 remaining shoulders were treated with a reverse shoulder prosthesis (RSP; DJO Surgical, Austin, TX). All surgeries were performed by 2 of the senior authors (M.F. and R.C.). When TSA or HA was performed, special attention was directed toward the exposure. Chronic posterior shoulder subluxation and deficient external rotation in OBPI patients may lead to shortening and hypertrophy of the anterior and

TABLE 1. Preoperative Characteristics

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Sex	M	F	M	M	F	M
Age at surgery (y)	60	77	50	66	56	66
Side	Left	Left	Left	Right	Left	Right
Dominant arm	Right	Right	Right	Right	Right	Left
Type of procedure	TSA	TSA	HA	RSA	RSA	RSA
Previous surgery	-	-	Subscapularis release + latissimus transfer	Arthroscopic debridement	-	-
Active motion						
Forward flexion	110	70	100	50	100	110
ER	0	−45	5	0	10	−30
IR	T8	L1	L5	L3	T4	L5
Pain	8	8	10	10	10	10
Glenoid version	39	61	56	10	-	29
Humeral implant version*	25	0	−5	−30	−30	−30

ER, external rotation; IR, internal rotation.
*Humeral version, + anteversion, − retroversion.

TABLE 2. Postoperative Characteristics

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Follow-up (mo)	157	126	63	108	60	24
Active motion						
Forward Flexion	70	70	70	140	60	110
ER	40	90	0	20	−30	0
IR	L4	L5	0	L5	Lateral ileum	T8
Pain	4	4	4	4	4	4
Glenohumeral instability						
Direction	Posterosuperior	Posterior	Posterior	None	None	None
Degree	Severe	Severe	Severe	-	-	-

ER, external rotation; IR, internal rotation.

middle deltoid. For these reasons, 1 of the senior authors (R.C.) elected to release the deltoid from the clavicle and anterior acromion in order to protect the deltoid from tearing during retraction for exposure. Additional release of the pectoralis major insertion was performed in 1 patient to further facilitate the exposure and mobilization of the shoulder joint. In all 3 patients treated with anatomical arthroplasty, the rotator cuff was found to be intact. A subscapularis peel was performed in all cases. In the patients undergoing TSA, limited asymmetrical reaming of the glenoid enabled partial correction of the glenoid version. Only minimal correction of the version was attempted in order to maintain the subchondral bone stock. One glenoid perforation occurred and was filled with local autograft (patient 2). A small glenoid implant was chosen and seated in a superior position. For the patient undergoing HA, the exposed bone of the glenoid was smoothed with a bur. All humeri were dysplastic and the version of the humeral head osteotomy varied greatly from standard procedures. No attempt was made to correct the humeral version, and the humeral stems were placed in the patient's native humeral version. These were placed in an average anteversion of 7°. The minimal alteration of glenoid version and the positioning of the humeral

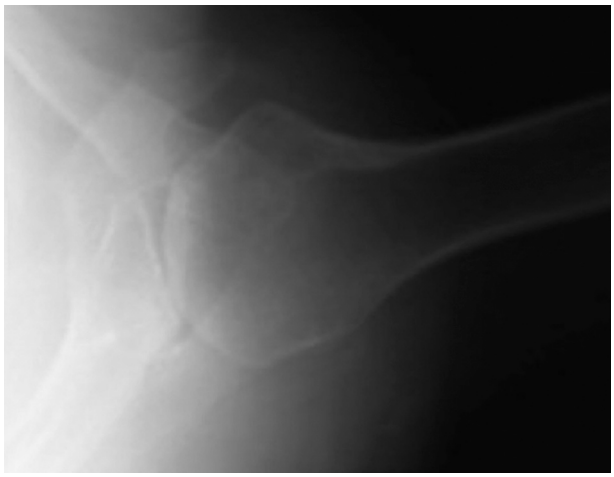

FIGURE 1: Axillary view of the left dysplastic glenohumeral joint of patient 1 with evidence of glenoid dysplasia, cartilage loss, and posterior subluxation.

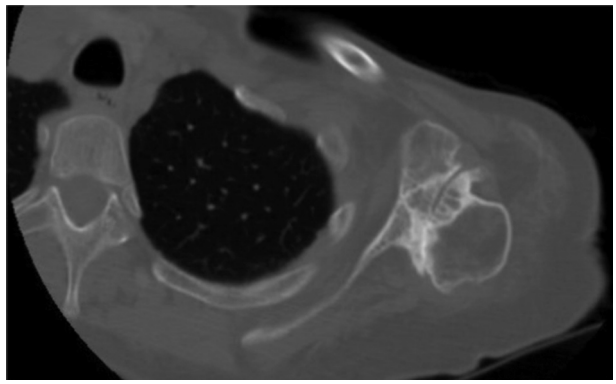

FIGURE 2: Computed tomography, axial view of the left dysplastic glenohumeral joint of patient 2.

component in anteversion served to best match the disease-altered lengths of the rotator cuff musculotendinous units. The posterior capsule was left intact and humeral head sizes were adjusted to correct posterior instability. In addition to the arthroplasty, 1 of the patients underwent an acromioplasty because of the significant downsloping of the acromion. This same patient (patient 2) had a significant internal rotation contracture and it was not possible to repair the subscapularis to its anatomical location. Instead, the subscapularis tendon was repaired in a side-to-side fashion to the supraspinatus and upper border of the detached pectoralis major. The detached pectoralis major tendon was mobilized and repaired superiorly to the proximal humerus, lateral to the lesser tuberosity. The anterior capsule was mobilized to cover the soft tissue defect that was created in the anterior aspect of the shoulder.

Three patients underwent RSA. In 1 case, a deltopectoral approach was performed and the anterior deltoid was released from the acromion to improve exposure. For the other 2 RSAs, a standard deltopectoral approach was utilized with particular attention to adequate release of the subdeltoid and subcoracoid spaces. Owing to the stabilizing effect of the RSA, complex soft tissue release/repair were not attempted. The humeral head was cut freehand and broached in 30° of retroversion. The humerus was dislocated anteriorly and all soft tissue was released from the posterior humerus. The glenoid was exposed in the window behind the anteriorly dislocated humerus. The glenoid was prepared to be slightly anteverted and glenosphere placement was completed in a standard fashion. Intraoperative motion was stable at 120° of forward elevation, 90° abduction, and 30° external rotation. The subscapularis was closed when possible using FiberWire (Arthrex, Naples, FL) through drill holes in the humerus.

RESULTS

All 6 patients were group 1 patients according to the Narakas classification with partial recovery and internal rotation contracture. Preoperative active motion was limited in all patients, with a mean forward elevation of 90° and external rotation −10°. All 6 patients had a preoperative internal rotation contracture and internal rotation averaged L1. Preoperative motion is detailed in Table 1.

At median follow-up of 7.1 years (range, 2−13.1 years), pain improved in all 6 patients regardless of the type of arthroplasty. Average pain scores improved from 9 to 4, with no patients reporting pain levels of 0.

At final follow-up, forward elevation was unchanged from a mean 90° to 87°. However, 5 of the 6 shoulders failed to improve their forward elevation following surgery. Only 1 RSA had improved forward elevation following shoulder arthroplasty. All shoulders treated with HA/TSA had forward flexion below 90°, compared with 1 out of the 3 patients treated with RSA. Detailed postoperative range of motion for each patient can be seen in Table 2. Internal rotation contracture improved from a mean −10° external rotation to 20°, active internal rotation decreased from L1 to L5.

Full results are detailed in Table 2. There were no intra- or postoperative complications.

All glenoids were Walch type C (Figs. 1−3), with an average glenoid retroversion of 48°. Posterior humeral head subluxation was severe in all cases. Median radiographic follow-up was 7.1 years

FIGURE 3: Anteroposterior view of the left dysplastic glenohumeral joint of patient 3 with cartilage loss. The humeral head is flattened and there is evidence of downsloping of the acromion and an elongated coracoid process.

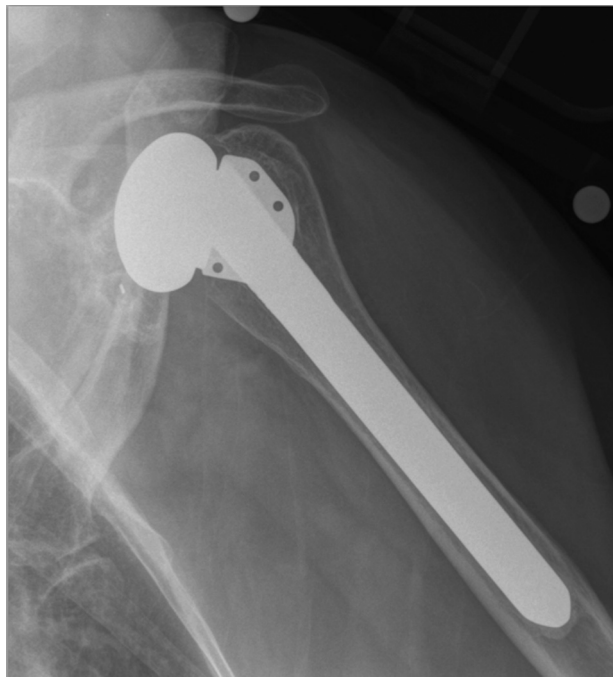

FIGURE 4: Anteroposterior view of the left shoulder of patient 1 at last follow-up shows moderate superior subluxation and no lucent lines.

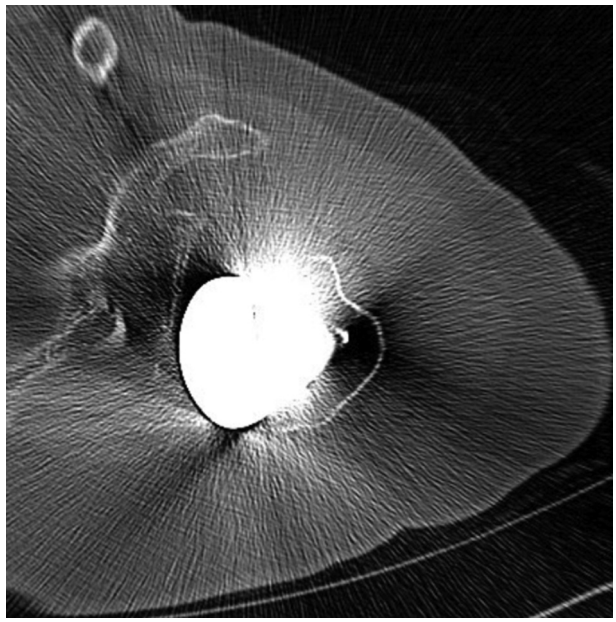

FIGURE 5: Computed tomography axial view of the left shoulder of patient 1 at last follow-up shows severe posterior subluxation.

(range, 2−13.1 years). Immediate postoperative radiographs showed severe posterior subluxation in all 3 patients treated with nonconstrained implants. This was found to be progressive over time and, at last follow-up, all 3 of these patients had either severe posterior or posterosuperior subluxation. No signs of loosening (radiolucent lines) were observed and no shift in the components was found (Figs. 4−6).

DISCUSSION

Early management of glenohumeral joint dysplasia is very challenging.[6,10,11] To our knowledge, there remains no described treatment that can reverse the process with these patients at higher risk of progression to symptomatic glenohumeral arthritis and loss of shoulder motion.[12] Although glenohumeral dysplasia is a very well-known consequence of OBPI, its management in older patients with symptomatic glenohumeral osteoarthritis is equally challenging and has not been previously reported.

Our findings indicate that shoulder arthroplasty is a good option to improve pain in these patients; however, improvement of shoulder motion was not demonstrated in most of the shoulders and varied significantly depending on the type of the implant chosen. It remains unclear why postoperative elevation did not improve in most patients. It is possible that the contracted soft tissues were insufficiently released. In addition, intraoperative soft tissue

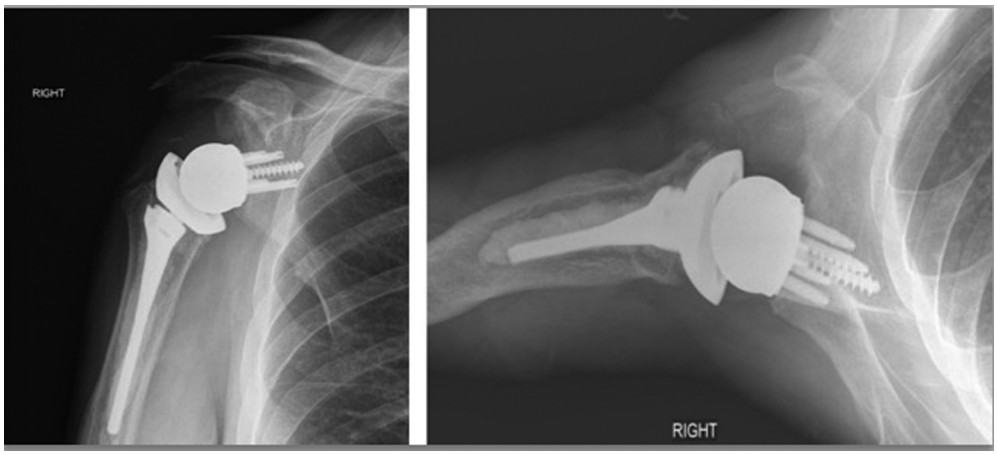

FIGURE 6: Anteroposterior and axillary views of the right shoulder of patient 6 at last follow-up show no lucent lines.

balancing may have resulted in an unbalanced force couple in these shoulders, resulting in the inability of the humeral head to maintain the stability required for overhead function. By medializing and lowering the center of rotation of the joint in a semiconstrained fashion, RSA enhances the moment arm of the deltoid and restores anterior flexion because good deltoid function is usually preserved in these patients. Limited shoulder external rotation in RSA may be related to reattachment of the contracted subscapularis as well as aggressive posterior soft tissue releases. In conjunction with potential weakness/atrophy of the infraspinatus seen in OBPI patients, subscapularis repair may limit the function of the remaining external rotators, which in turns limits functional external rotation. In addition, because of preoperative internal rotation contractures and subscapularis shortening, we now prefer to leave the subscapularis unrepaired in these patients. Recently, Rudge et al[13] have reported the results of linked prostheses for this patient population. Similar to our study on unconstrained and semiconstrained implants, Rudge et al[13] showed improvement of pain but not function. Higher scores in the operated shoulders were due to better relief of pain. The mean range of active forward elevation and abduction remained clinically similar from before to after surgery (35° to 39° and 46° to 45°, respectively). Mean external rotation improved from −17° to −4°. Moreover, 3 of 9 of the patients in their series required reoperation, which is similar to our experience (2 of 6 shoulders).

Patients with OBPI may compensate for limited glenohumeral motion through their scapulothoracic articulation. Patients adapt at an earlier age to the loss of the glenohumeral motion secondary to shoulder subluxation/dislocation by increasing the scapulothoracic motion and, thus, global shoulder motion. The single case report addressing arthroplasty in Erb palsy patients discusses the many surgical challenges, including posterior capsule tightness and extreme retroversion of the glenoid and humeral head.[14] In this case, the patient required several additional operations after undergoing a hemiarthroplasty. In addition, Sewell et al[15] described their results with shoulder arthroplasty for dysplasia as effective at relieving pain but resulted in higher revision rates and less consistent improvement in funtion. Unlike these previous reports, reoperation was not required in any patient in this small series. In 2014, Allen et al[16] described otucomes of HA and TSA in patients with glenoid dysplasia without neurological deficits. They reported that favorable results can be obtained, but continued subluxation and glenoid component failure necessitating revision surgery are frequent. Despite progressive posterior subluxation in the 2 anatomical TSAs in this series, neither patients had developed signs of glenoid component loosening. This could be due to the weaker muscle power around the shoulder and less loading on the implant.

Management of these uncommon, challenging cases requires a thorough preoperative evaluation that includes a detailed physical examination and advanced axial imaging to evaluate glenoid bone stock and the rotator cuff muscles. Surgeons should be careful when exposing these shoulders because the humeral head is posteriorly subluxed with medialization of the subscapularis insertion within the deltopectoral interval. In addition, care should be taken to preserve the anterior deltoid insertion, which may require release from the acromion to prevent avulsion.

In conclusion, shoulder arthroplasty is an acceptable option to relieve pain in patients with symptomatic shoulder arthritis as a sequel of OBPI. However, range of motion improvements are not expected.

ACKNOWLEDGMENTS

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

Investigation performed at the Mayo Clinic, Rochester, MN.

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