Reverse shoulder arthroplasty in 41 patients with cuff tear arthropathy with a mean follow-up period of 5 years

Nawfal Al-Hadithy, MRCS*, Peter Domos, MRCS, Mathew D. Sewell, FRCS, Ravi Pandit, FRCS

Luton and Dunstable Hospital, Luton, UK

Background: Reverse shoulder arthroplasty (RSA) is an accepted treatment for patients with pseudoparalysis due to cuff tear arthropathy. There have been limited studies with midterm clinical and radiologic results. We present our results for a single surgeon from a district general hospital.

Methods: Forty-one consecutive Delta III RSAs were performed by an anterosuperior approach in 37 patients (29 women and 8 men) with pseudoparalysis due to cuff tear arthropathy. The patients’ mean age was 79 years (range, 68-91 years). The mean follow-up period was 5 years. All patients were available for final review, and none were lost to follow-up.

Results: The mean age-adjusted Constant and Oxford scores improved from 34.2 points to 71.0 points and 15 points to 33 points, respectively. Mean abduction and forward flexion improved from 64° to 100° and 55° to 110°, respectively. Scapular notching was seen in 68% of patients, but there was no deterioration in function or satisfaction scores. Stress shielding of the proximal humerus was seen in 10% of patients. One patient underwent revision to a hemiarthroplasty because of glenoid component failure after a fall. There were no early postoperative dislocations in our series.

Conclusion: RSA for pseudoparalysis due to cuff tear arthropathy provides good functional results at 5 years; however, there is a high rate of scapular notching, which does not seem to affect overall functional outcomes.

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

Successful surgical management of cuff tear arthropathy is challenging, and the excellent results of unconstrained arthroplasty in primary glenohumeral arthritis have not been replicated in cuff tear arthropathy.12 The early failures of total shoulder arthroplasty due to eccentric loading of the glenoid component meant that hemiarthroplasty remained the surgical option of choice for most surgeons, despite inconsistent relief of pain and poor function.10,29,30

The Delta III reverse shoulder arthroplasty has been used more recently and provides better functional outcomes than hemiarthroplasty because of a medialized center of rotation, which reduces torque on the glenoid component and increases the mechanical advantage of the deltoid.1 Despite concerns about scapular notching and failure rates, indications and implantations have been increasing. There have been numerous studies reporting the outcome of the Delta III prosthesis; however, they are limited by short...
Materials and methods

Between 2002 and 2010, 41 consecutive Delta III reverse shoulder arthroplasties were performed in 37 patients (29 women and 8 men) with symptomatic cuff tear arthropathy. The mean age of the patients was 79 years (range, 68-91 years). A total of 4 patients underwent bilateral procedures. Surgery was performed on the right shoulder in 31 cases and on the left shoulder in 10 cases. The main indication for implantation was severe pain with functional impairment and pseudoparalysis, with radiologic signs of glenohumeral arthritis and proximal migration of the humeral head. Patients with active sepsis, avascular necrosis, rheumatoid arthritis, post-traumatic arthritis, and symptomatic acromioclavicular joint arthritis were not included in the study. All patients were deemed to have an intact subscapularis tendon by clinical examination.

Preoperative and postoperative clinical and functional outcomes were measured with the Oxford and Constant shoulder scores by 2 independent surgeons who were not involved with the original operation. The Oxford score is a validated 12-question patient-reported scoring system evaluating pain, function, and range of motion. It ranges from 0 points (worst) to 48 points (best). The Constant score is a 100-point validated scoring system that is patient reported and clinician assessed and covers pain, function, range of motion, and strength.

Anteroposterior, lateral, and axillary radiographs were obtained in all patients at 6 weeks and 6 months, as well as yearly thereafter.

Serial radiographs were evaluated for component malposition, periprosthetic radiolucency, scapular notching, stress shielding, heterotrophic ossification, and prosthesis failure by 2 independent assessors. Scapular notching was graded according to the classification of Sirveaux et al. (Table I). Radiolucent lines were assessed according to the criteria of Sperling et al.

All operations were performed by the senior author (R.P.) with patients under a general anesthetic, supplemented with an interscalene block. The anterosuperior McKenzie approach was used. The subscapularis tendon was inspected and confirmed to be intact in all cases. The humeral neck was resected by use of the appropriate jig. All components (glenoid baseplates and humeral stems) were uncemented and hydroxyapatite coated. The glenosphere was implanted in a neutral position as inferiorly as possible, in an effort to achieve an inferior overhang as described by Nyffeler et al. The glenoid baseplate was held in place with 4-mm peripheral locking screws. The size of the glenosphere was determined by the size that helped achieve the best soft-tissue tension and stability. Humeral stems were implanted in 10° of retroversion.

The postoperative antibiotic protocol consisted of 1 intravenous dose of 1.5g cefuroxime. The arm was placed in a sling to immobilise the shoulder joint. Physiotherapy was started on day 1 and included full unrestricted passive-assisted mobilization, progressing to gradually increase function by 4 to 6 weeks. Concentric strengthening was increased at 6 weeks postoperatively, after which use of the sling was discontinued.

Statistical analysis

The Constant and Oxford scores were normally distributed. The paired t test was therefore used to compare the preoperative and postoperative scores. All analyses were performed with SPSS software program (version 9.0; SPSS, Chicago, IL, USA). P < .05 was considered significant.

Results

All patients were available for follow-up at a mean of 60 months (range, 20-101 months) (Fig. 1). Patients were split into 2 groups depending on whether they had more or less than 48 months’ follow-up. There were 9 shoulders (group 1) with less than 48 months’ follow-up and 32 shoulders (group 2) with more than 48 months’ follow-up.

Functional outcome

On subjective assessment, 20 patients (49%) felt that their shoulder was much better, 11 (27%) thought it was better, 6 (15%) were unsure, and 3 (7%) thought it was worse. The preoperative and postoperative Constant and Oxford scores are reported in Table II and range of motion in Table III. There were significant gains (P < .05) between preoperative and postoperative scores (24 months and final follow-up periods and by varying indications for implantation, including revision, fracture, and nonunion, making it difficult to reliably compare results. Other articles have reported on multicenter studies involving different surgeons, with variations in surgical techniques and postoperative rehabilitation leading to confounding factors, making interpretation of results difficult.

We present the midterm clinical and radiologic results of primary Delta III prostheses for cuff tear arthropathy performed by a single surgeon in a district general hospital, in patients with no previous surgical procedures, with a mean follow-up period of 5 years.

### Table I  Sirveaux classification of scapular notching

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Defect confined to pillar</td>
</tr>
<tr>
<td>2</td>
<td>Defect reaches lower screw</td>
</tr>
<tr>
<td>3</td>
<td>Defect crosses lower screw</td>
</tr>
<tr>
<td>4</td>
<td>Defect extends under baseplate</td>
</tr>
</tbody>
</table>

Figure 1  Follow-up duration in months.
up); however, there was no significant difference between the 24-month and final follow-up scores, although there was a trend toward reduction in function.

Radiographic outcome

Radiographs were obtained preoperatively, immediately postoperatively, and at most recent follow-up and were available for review.

Scapular notching was noted in 28 shoulders (68%) and was assessed by the Sirveaux classification 33: 22 shoulders (54%) had grade 1 or 2 notching, and 6 patients (15%) had grade 3 or 4 notching (Fig. 2). In all cases, notching was visible on radiographs at 12 months, but only 3 progressed with time, from grade 2 to 3 in 2 patients and from grade 2 to 4 in 1 patient. There was no observed association between progression of scapular notching and deterioration of Constant or Oxford scores at 24 months and final follow-up.

Two patients had malpositioned screws (1 inferior and 1 posterior) on initial radiographs (Fig. 3) However, both had an uneventful postoperative course, with no evidence of further loosening or screw cutout. Five patients (12%) had radiolucent lines, with 3 (7%) around the glenoid component in zones 1 and 2; all were less than 2 mm in width and non-progressive. Two patients had humeral radiolucent lines in zones 7, 8, and 9, but they were less than 1 mm and non-progressive.

The presence of stress shielding was defined as thinning of either medial or lateral cortical bone with osteopenia as classified by Melis et al. 24 Four patients had medial proximal humeral stress shielding. In all cases, it was non-progressive and confined to the metaphysis without any signs of aseptic loosening. Three of these patients had scapular notching as well. Periprosthetic heterotrophic ossification was present in 42% of patients.

Complications

Of the patients, 4 (10%) had complications, with 1 undergoing revision surgery. Two patients had post-traumatic glenoid component failure. One patient fell 6 weeks

<table>
<thead>
<tr>
<th>Table II</th>
<th>Mean constant, age-adjusted constant, and Oxford scores preoperatively and postoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant score (points)</td>
</tr>
<tr>
<td>Group 1: Shoulders with &lt;48 mo of follow-up (n = 9)</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>26</td>
</tr>
<tr>
<td>24 mo postoperatively</td>
<td>54</td>
</tr>
<tr>
<td>Final follow-up</td>
<td>53</td>
</tr>
<tr>
<td>Group 2: Shoulders with &gt;48 mo of follow-up (n = 32)</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>23</td>
</tr>
<tr>
<td>24 mo postoperatively</td>
<td>65</td>
</tr>
<tr>
<td>Final follow-up</td>
<td>64</td>
</tr>
<tr>
<td>All shoulders</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>24</td>
</tr>
<tr>
<td>24 months postoperatively</td>
<td>63</td>
</tr>
<tr>
<td>Final follow-up</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table III</th>
<th>Mean range of motion preoperatively and postoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of scoring</td>
<td>Flexion (°)</td>
</tr>
<tr>
<td>Group 1: Shoulders with &lt;48 mo of follow-up (n = 9)</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>56</td>
</tr>
<tr>
<td>24 mo postoperatively</td>
<td>98</td>
</tr>
<tr>
<td>Last postoperative visit</td>
<td>101</td>
</tr>
<tr>
<td>Group 2: Shoulders with &gt;48 mo of follow-up (n = 32)</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>54</td>
</tr>
<tr>
<td>24 mo postoperatively</td>
<td>124</td>
</tr>
<tr>
<td>Last postoperative visit</td>
<td>111</td>
</tr>
<tr>
<td>All shoulders</td>
<td></td>
</tr>
<tr>
<td>Preoperatively</td>
<td>55</td>
</tr>
<tr>
<td>24 mo postoperatively</td>
<td>118</td>
</tr>
<tr>
<td>Last postoperative visit</td>
<td>108</td>
</tr>
</tbody>
</table>

ER, external rotation; IR, internal rotation; SI, Sacro-iliac
postoperatively, causing the glenoid component to migrate superiorly (Fig. 4, A and B). At 2 months, he underwent revision to a hemiarthroplasty (Fig. 4, C); although he was pain free, he had limited abduction of 40°. The other glenoid component failure occurred in an 88-year-old low-demand patient from a nursing home, who—after a fall—had minimal superior migration of the glenoid component in her nondominant hand. Because she was able to abduct her shoulder to 50° and had minimal pain, she declined further intervention.

One patient fell 5 months after surgery and sustained a minimally displaced fracture of the acromion. The shoulder was treated nonoperatively with a period of immobilization and healed uneventfully.

One patient had a broken superior glenoid screw (Fig. 5) at 18 months after initial surgery without any history of trauma. He had the lowest functional scores with some occasional pain but preferred nonoperative management. He was monitored regularly with radiographs, but no glenoid loosening or other complications occurred.

Of the 9 patients (22%) who were either unsure or unhappy about the outcome of their procedures, 4 were the patients who had complications. Of the remaining 5 patients, all complained of persistent pain; however, despite serial review including inflammatory markers and radiologic evaluation, no cause was identified, and these patients were managed expectantly. Of the 5 patients, 1 did not have scapular notching; the remaining 4 had grade 1 or 2 notching and the notching was non-progressive.

Discussion

Over the past decade, reverse shoulder arthroplasty has increasingly been used for cuff tear arthropathy. With increasing surgical confidence, the indications have also extended to now include rheumatoid arthritis, massive cuff tears, fracture sequelae, and revision after hemiarthroplasty.19 Our study has shown that the Delta III prosthesis can improve pain and function in patients with cuff tear arthropathy, with a low complication rate; however, movement and function seems to deteriorate over time.

There were significant gains in Oxford scores (15 points to 32 points) and Constant scores (24 points to 60 points) in both patient groups of patients; however, we found lower increases in range of motion compared with other studies that evaluated cuff tear arthropathy.7,13,18 This may be partly explained by our longer follow-up period of 60 months compared with a mean of 29 months. We noted general deteriorations in functional scores and range of motion after 24 months to final follow-up. Favard et al9 performed a survivorship analysis of 527 reverse shoulder arthroplasties and found that although revision rates at 10 years were relatively low (11%), functional scores deteriorated with time. Although they suggested that the reason for this is unknown, others have hypothesized that over-tensioning the deltoid muscle and periscapular muscle fatigue may be responsible.21,23

In a series of 60 patients, Frankle et al11 found a glenoid baseplate failure rate of 12% at 21.4 months’ follow-up and

Figure 2  Anteroposterior radiograph of left shoulder showing scapular notching due to mechanical impingement by medial rim of humeral cup.

Figure 3  Malpositioned glenoid screw penetrating through the cortex of the scapula.

There were no cases of superficial or deep infection, loosening, dislocations, periprosthetic fractures, or axillary nerve injuries. Thus far, no patients in our series have undergone revision for loosening or scapular notching.
attributed it to the use of 3.5-mm peripheral screws for fixation. Harman et al\textsuperscript{18} found that using peripheral screws of 5 mm reduced micromotion at the baseplate-bone interface to less than 150 $\mu$m, which is generally the accepted threshold for bony ingrowth.\textsuperscript{20} In their follow-up study, Cuff et al\textsuperscript{4} secured the baseplate with 5-mm screws and found no cases of loosening at 27.5 months. A further study evaluated 96 shoulders, in which the baseplate was secured with locking screws, and no failures were noted at 2 years’ follow-up.\textsuperscript{3} Frankle et al found that their 8 failures occurred because of metal fatigue of the glenoid baseplate screws at a mean of 21.4 months, and they suggested that the first 2 years was a critical period because failure of bony ingrowth could result in early failure. We elected to use 4-mm peripheral locking screws and had 2 instances of baseplate failure and 1 case of screw breakage, all of which occurred within 24 months from surgery. The use of locking screws may contribute to malpositioning of the screw due to a lack of adequate tactile feedback.

Several studies have suggested that an inferior tilt of the glenoid baseplate reduces scapular notching by reducing it reduces inferomedial impingement of the humerus against the pillar of the scapula. However, these are based mostly on retrospective observations.\textsuperscript{2,14,18} More recently, biomechanical studies have suggested that inferior translation of the glenosphere allowing overlap of the inferior glenoid rim may be more important than inferior tilt alone.\textsuperscript{5,16,28} In a prospective randomized study, Edwards et al\textsuperscript{7} found that a computer-navigated inferior tilt of 10° did not reduce the incidence or severity of scapular notching. Although their follow-up period was limited, at 21 months, other authors have shown that notching appears within 2 years and tends not to progress past that time point.\textsuperscript{14} Grassi et al\textsuperscript{14} found that an inferior overhang did not prevent progression of scapular notching. Although we aimed to position the glenoid baseplate in the neutral position, with an inferior overhang of 3 to 4 mm, Levigne et al\textsuperscript{22} found that there was a tendency to position the glenosphere with a superior tilt and superior placement with the superolateral approach when compared with the deltopectoral approach. Melis et al\textsuperscript{24} found notching to be more prevalent with the superolateral approach (23 of 35 cases) than with the deltopectoral approach (9 of 30 cases); however, they did not assess for glenoid implant positioning and noted that many surgeons did not aim for inferior positioning of the baseplate on the glenoid. Gutierrez et al\textsuperscript{17} found that an inferiorly tilted glenoid had the most uniform compressive forces and less tensile force and micromotion compared with a superiorly tilted baseplate and found that a superior tilt predisposed patients to early failure.

Figure 4  (A) Postoperative radiograph after reverse shoulder arthroplasty. (B) At 2 months after a fall, the glenoid component failed with superior migration. (C) Revision to a hemiarthroplasty was performed, and although function was limited, the patient was pain free.

Figure 5  Anteroposterior radiograph of left shoulder postoperatively (A), with subsequently broken superior screw (B). A radiolucent area is seen around the central peg (B), showing that the implant is toggling.
Our findings are consistent with those of Edwards et al., and our notching rate of 68% was consistent with other studies with rates ranging from 50% to 96%. It therefore appears that inferior glenosphere tilt does not reduce the incidence of scapular notching. In line with other studies, we found no relation between scapular notching and function or pain at 24 months or final follow-up. Recently, several authors have attempted to reduce scapular notching rates by increasing the offset of reverse shoulder arthroplasty. Frankle et al. reported successful clinical outcomes with the Reverse Shoulder Prosthesis (DJO Surgical, Austin, TX, USA), which has a center of rotation closer to its anatomic location. In a further study evaluating the Reverse Shoulder Prosthesis, Cuff et al. found no instances of scapular notch-location. In a further study evaluating the Reverse Shoulder Prosthesis, Cuff et al. found no instances of scapular notch-location. These results are consistent with those of Sirveaux et al., where we found that 3 of our 4 patients with proximal humeral bone resorption had associated scapular notching. We noticed that proximal humeral resorption occurred predominantly on the medial cortex, and this may be due to direct impingement on the inferior scapula, therefore causing both scapular notching and proximal humeral resorption.

Our complication and revision rates of 10% and 2%, respectively, are lower than those in other series. Zumstein et al reviewed 21 studies and found complication, reoperation, and revision rates of 24%, 3.5%, and 10%, respectively, with reoperations being defined as interventions requiring return to the operating theater without altering or replacing the components and revisions defined as total or partial exchange of the components. We attribute our low complication rate to a combination of factors—surgical approach, implant development, preferential implantation of the prosthesis in the neutral position with an inferior overhang, and an elderly population (79 years) with low demands. The most common and serious complication is dislocation, with an incidence of up to 9%, . Zumstein et al. found that 97.3% of dislocated shoulders requiring reoperations in those that were performed using the deltopectoral approach, and this was the most common cause of reoperation. Mole et al. reviewed 527 reverse shoulder arthroplasties and found significantly lower instability rates with the anterosuperior approach (0.8%) compared with the deltopectoral approach (5.1%). In our series, we used the anterosuperior approach exclusively and had no dislocations; in addition, surgery was only performed in shoulders with an intact subscapularis tendon, which has been shown to halve the incidence of dislocation. Several studies also used the first Grammont prosthesis, where glenoid disassembly was a problem. This has since been resolved by introducing a modified Morse taper fixation for the glenosphere on the metaglene.

We acknowledge the limitations of this study being retrospective. Scapular notching is difficult to assess if the X-ray beam is not aligned and perpendicular to the baseplate. Furthermore, although we aimed for an inferior tilt, radiographic assessment was abandoned because we found inter-observer variability to be unacceptable, which we attributed to the variability in positioning of the radiographs and the lack of accuracy of plain radiographs. We minimized assessment bias by having 2 independent assessors who were not involved with the index operation perform the evaluations.

Conclusion

Our experience with Delta reverse shoulder replacement for cuff tear arthropathy performed by a single surgeon from a district general hospital has been encouraging. Patients with cuff tear arthropathy can expect significant improvements in function and pain, with an acceptable complication rate at 5 years. There is a high incidence of scapular notching; however, no association was seen with functional outcome. We continue to use the Delta III reverse shoulder prosthesis for cuff tear arthropathy and are encouraged by the outcomes and low complication rates in this elderly population.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

6. De Wilde LF, Poncet D, Middernacht B, Ekelund A. Prosthetic overhang is the most effective way to prevent scapular conflict in a


