Title:

Revision shoulder arthroplasty for failed humeral head resurfacing hemiarthroplasty.

Short title:

Revision of failed humeral head resurfacing

Key words: hemiarthroplasty; resurfacing; revision surgery; shoulder arthritis; shoulder replacement; total shoulder replacement

Abstract

Background:

The purpose of this study was to analyse and report the clinical outcomes following **revision shoulder arthroplasty for failed humeral head resurfacing hemiarthroplasty (HHRH).**

Materials and Methods:

All patients who underwent **revision shoulder arthroplasty for failed HHRH** at our institution were retrospectively reviewed. Twenty-two shoulders in 20 patients were available for analysis. Mean age at the time of HHRH was 60 years (range, 42- 75). The cohort consisted of 17 females and three males.

Results:

The mean time from HHRH to revision was 5 years (range, 1-8 years). Mean age at the time of revision surgery was 62 years (range, 44-80). Patients were followed-up for a mean of 3.3 years (range, 2–4 years) after revision. Following revision surgery, there was an increase in forward elevation from 67^0 (range, 0-130^0) to 97^0 (range, 40-160^0) (P=0.04). This was accompanied by an improvement in both the Oxford shoulder score and the subjective shoulder value, which increased from 13 (range, 2-28) to 39 (range, 24-48) (P=0.000) and from 23 (range, 0-65) to 79 (range, 25-100) (P=0.000) respectively.

Conclusion:

Revision shoulder arthroplasty for failed HHRH improves functional outcome.

Level of evidence: Level IV; Case series

Introduction

The National Joint Registry (NJR) for England, Wales, Northern Ireland, and the Isle of Man reported that 714 resurfacing total and hemi-arthroplasty procedures were performed in 2014, accounting for 15% of all primary shoulder replacements. [1] **Humeral head resurfacing hemiarthroplasty (HHRH) is most commonly undertaken for osteoarthritis of the shoulder**. [1-3] Resurfacing arthroplasty requires limited bone resection and is frequently considered for young, active patients who are likely to undergo revision surgery at some point in their lives. [4] Its advantages include the potential for accurate restoration of articular retroversion, neck-shaft angle, offset, and center of rotation. [5, 6] Revision surgery is facilitated because the prosthesis can be removed with virtually no bone loss from the proximal humeral metaphysis and a glenoid prosthesis can be implanted if indicated. [7] **Technical difficulties associated with resurfacing arthroplasty are predominantly due to incorrectly sizing and orienting the prosthesis resulting in "over-stuffing" of the joint.** [8] Few studies have evaluated the results following revision total shoulder arthroplasty (TSA) for failed HHRH.[9, 10] Those that do report variable outcomes that are often disappointing. [9, 10]

Understanding the reasons for failure of HHRH and the outcome of subsequent revision is essential for patient counseling and future prosthetic design. The aim of this retrospective cohort study was to analyse and report the clinical outcomes of a consecutive series of patients who underwent **revision shoulder arthroplasty following failure of a resurfacing hemiarthroplasty prosthesis.**

Materials and Methods

Between September 2009 and January 2014 20 consecutive patients **underwent revision shoulder arthroplasty for failed HHRH** at our study institution. Two patients had bilateral procedures allowing 22 shoulders to be available for analysis. All cases were identified using a computerized database and were performed by the senior authors (MF, DH, and SML). The indication for HHRH was primary osteoarthritis in 16 shoulders, rheumatoid arthritis in four shoulders, and rotator cuff tear arthropathy in two shoulders. Resurfacing components included 22 Copeland Surface Replacement Arthroplasty (CSRA, Biomet, Swindon, United Kingdom) prostheses. All index procedures were performed elsewhere and referred to our complex shoulder unit for further evaluation. **If there was a strong clinical suspicion of infection preoperatively, intra-articular fluid and tissue samples were taken in the operating theatre before revision and evaluated for organisms such as *Propionibacterium acnes*.**

Mean age at the time of HHRH was 60 years (range, 42- 75). The cohort consisted of 17 females and three males. The dominant arm was affected in 12 cases. Two patients underwent other prior surgery, comprising two acromio-clavicular joint excisions. **Reasons for failure included glenoid erosion in 18 shoulders, rotator cuff tear arthropathy in two shoulders, and painful stiffness without glenoid erosion in two shoulders. No cases of peri-prosthetic infection were noted in the cohort.**

Surgical technique

Index surgery was carried out using a deltopectoral approach in 18 shoulders and an antero-lateral (deltoid splitting) approach in four shoulders. The deltopectoral approach was used for revision in all cases. Subscapularis was detached from its insertion in external rotation and subsequently repaired directly to bone. The rotator cuff was examined to determine whether an anatomical or reverse anatomy replacement was most suitable. The following parameters were evaluated intra-operatively: prosthetic loosening, implant position, implant size, bone resorption under the implant, glenoid cartilage loss, articular bone loss, and the presence of a rotator cuff tear. [10] Glenoid bone loss was treated with morcelised humeral head autograft compressed beneath a metal-back glenoid.

Radiographic assessment

Pre- and post-revision radiographs were performed in all cases and included antero-posterior and axillary views. **Plain radiographs were reviewed for the presence of glenohumeral subluxation, periprosthetic lucency, and glenoid erosion.** [11, 12] **Computer tomography (CT) was used to evaluate glenoid bone stock to ensure that a glenoid component could be placed.** Following revision surgery, all reverse anatomy prostheses were additionally assessed for scapular notching and classified according to the size of the defect on the antero-posterior radiograph using the four-part grading system devised by Sirveaux et al. [13]

Glenohumeral subluxation was assessed by evaluating the direction and the amount of translation of the center of the prosthetic head relative to the center of the glenoid or the glenoid component. It was graded as present if translation was greater than 25% and absent when translation was less than 25%. [14] Periprosthetic loosening was evaluated by assessing the glenoid and humeral components for lucent lines and an alteration in position. [12] For the glenoid, this was defined as migration/tilting of the component or a complete lucent line with part of it measuring at least 1.5 mm in width. Loosening of a humeral prosthesis was identified by a lucent line at least 2 mm in width or tilting/subsidence of the implant.

Glenoid erosion was graded as none, mild if there was erosion into subchondral bone, moderate if there was medialisation of the glenoid subchondral bone with associated hemispheric deformation of the glenoid, or severe, if there was complete hemispheric deformation of the glenoid with bone loss to the base of the coracoid. [11]

Clinical assessment

Clinical outcome measures examined pre- and post-revision surgery included active forward elevation and active external rotation. All patients were evaluated with the Oxford Shoulder Score (OSS). In addition all patients were assessed using the subjective shoulder value (SSV), which uses a scale from 0 (worst score) to 100 (best score) to describe the affected shoulder. [15] This can be used as a supplementary tool to traditional, more complex outcome measures and may be used in conjunction with other scores to assess the patients' outcome.

Statistical analysis

The paired t test was used to compare range of motion, OSS, and SSV before and after surgery. A P value of < 0.05 was considered significant. The SPSS software package, version 23 (SPSS Inc, an IBM Company, Chicago, Illinois) was used to analyse data.

Results

The mean interval from **HHRH to revision shoulder arthroplasty** was 5 years (range, 1-8 years). Mean age at the time of revision surgery was 62 years (range, 44-80). Patients were followed-up for a mean of 3.3 years (range, 2–4 years).

Intra-operative evaluation

Intra-operative assessment at the time of revision demonstrated loosening in eight shoulders, an excessively large implant in five shoulders, bone resorption in the proximal humerus in 11 shoulders, a rotator cuff tear in 10 shoulders, a deficient subscapularis in 3 shoulders, glenoid cartilage loss in 22 shoulders, and glenoid bone loss in 12 shoulders. The coronal alignment of the implant was considered neutral in 17 shoulders, varus in four shoulders, and valgus in one.

Choice of revision implant was determined by preoperative radiological assessment and the aforementioned intra-operative findings. An 'off the shelf' reverse anatomy implant was used in the presence of a rotator cuff tear and a computer-assisted design/computer-assisted manufacturing (CAD/CAM) prosthesis was used in cases where bone loss precluded safe implantation of a conventional glenoid component. Anatomical TSA was used in all remaining cases. Revision surgery was undertaken using an Epoca (DePuySynthes, Leeds, UK) anatomical TSR with a metal-backed glenoid in 11 cases (Figure 1), a fixed fulcrum fully constrained reverse anatomy prosthesis (Stanmore Implants, Elstree, UK) in six cases (Figure 2), and a CAD/CAM TSA (Stanmore Implants, Elstree, UK) in five cases (Figure 3). **Impaction grafting using morcelised humeral head autograft was used to treat glenoid bone loss in six cases.**

Radiological assessment

Analysis of resurfacing prostheses before revision surgery demonstrated subluxation in 19 cases **(superior and anterior in 5 cases, superior and posterior in 5 cases, superior in 3 cases, anterior in 5 cases, and posterior in 1 case)**, loosening in three cases, moderate glenoid erosion in 10 cases, and severe glenoid erosion in 16 cases. Following revision surgery, evaluation of all TSA implants revealed subluxation in six cases **(anterior in 4 cases, posterior in 1 case, and superior in 1 case)** and loosening of the glenoid component in two cases. Scapular notching was not present in any of the reverse anatomy prostheses at the latest follow-up.

Clinical outcomes

Mean active forward elevation increased from 67^{0} (range, 0-130^{0}) to 97^{0} (range, 40-160^{0}) (P=0.04) following revision surgery. An improvement was also noted in mean active external rotation, which increased from 25^{0} (range, 0-70^{0}) to 34^{0} (10-70^{0}) (P=0.111) following revision surgery.

The mean OSS improved from 13 preoperatively (range, 2-28) to 39 postoperatively (range, 24-48) at the final follow-up (P=0.000). An increase was also noted in the mean SSV, which improved from 23 (range, 0-65) preoperatively to 79 (range, 25-100) postoperatively (P=0.000).

Complications

Further revision surgery was required in one patient, with a fixed fulcrum fully constrained reverse anatomy prostheses, due to loosening of the glenoid component. In this case, an isolated glenoid replacement was undertaken, which resulted in an improvement in both the OSS and the SSV. No other complications were noted in the cohort.

Discussion

HHRH is a well-established treatment modality for osteoarthritis of the shoulder, but its use has been expanded to include cases of rheumatoid arthritis, isolated chondral defects, osteonecrosis, and cuff tear arthropathy. [2, 10, 16, 17] Good clinical results have been reported in the short- and mid-term following resurfacing arthroplasty but registry data has demonstrated a cumulative five-year revision rate of approximately 10%, **with reasons for failure infrequently discussed. [9, 10, 18]**

Using the Danish Shoulder Arthroplasty Registry, Rasmussen et al [9] evaluated the results of revision shoulder arthroplasty after resurfacing hemiarthroplasty in patients with osteoarthritis. 107 cases were identified, of which 80 were followed up with postoperative functional outcome assessment only. Of these, 33 (41%) had an unacceptable outcome, defined as a Western Ontario Osteoarthritis of the Shoulder (WOOS) index of ≤ 50 points. Further revision surgery was required in 11 cases (10%). Streubel et al [10] reported the results of 11 patients that underwent revision of a HHR implant. After a mean follow-up of 3.5 years, an unsatisfactory outcome was noted in six cases and further surgery was required in two cases (one haematoma and one revision for instability).

Our results suggest that failed HHRH can be successfully revised with a range of implants. Revision surgery was carried out a mean of five years after the index procedure, and the most common reason for failure was glenoid erosion causing pain. At short-term follow-up there was an increase in external rotation, a significant improvement in forward elevation, and a significant improvement in functional outcome. This is contrary to other reports evaluating the results following revision shoulder arthroplasty for failed humeral resurfacing, where an unsatisfactory outcome was frequently noted. [9, 10] At the time of revision, eight implants were found to be loose although only three of these were evident on preoperative radiographs. One re-operation was undertaken for glenoid loosening in a patient with a reverse total shoulder replacement, but there was still an improvement in functional outcome.

Success of a cementless prosthesis (such as HHRH) is dependent upon firm contact between the implant and the bone, and bony ingrowth onto the implant surface. [19-21] Resurfacing arthroplasty affects load transfer and induces stress shielding, leading to excessive bone resorption and loosening. [19, 22, 23] Conventional radiographs are unable to accurately assess the bearing bone as it is covered by the radiopaque shell of the prosthesis. [22] In a recent study examining osteointegration in two resurfacing shoulder implants (Copeland and Epoca) without clinical evidence of loosening, limited bone was observed around the central stem of the CSRA, in contrast to the Epoca Resurfacing Head prosthesis (Synthes, Oberdof, Switzerland) where there was uniform bone contact over the entire surface. [24] In a similar study, Schmidutz et al [22] investigated the bone-implant interface in four different HHRH implants: CSRA (n=5), Epoca (n=7), Capica (Implantcast, Germany, n=1), and Global C.A.P. (n=1). Stress shielding and reduced bone stock under the implant shell was observed in the majority of cases. For stemmed prostheses such as the CSRA, bone stock was reduced between the central stem and outer rim. Alternatively, in conical-crowned implants such as the Epoca, bone stock was predominantly reduced at the inner margin of the crown.

All implants examined in this study were CSRA prostheses. Stress shielding could potentially be responsible for the bone resorption found in 50% of cases (11 out of 22 shoulders) in this study as this has been previously demonstrated in a finite element analysis of CSRA. [25] This did not manifest radiologically in all patients as it may have been preceded by failure due to other reasons such as glenoid erosion. Radiological lucency in the medium-term has been demonstrated to occur in 18% of cases, but this may be an underestimation since the area of bone beneath a resurfacing arthroplasty is covered and therefore not visible on plain radiographs. [3] Glenoid bone loss was observed in 55% (12 out of 22 shoulders) of patients and is an important consideration for revision surgery as the limited bone stock may preclude safe glenoid implantation. In some cases this may require either glenoid reconstruction using bone graft or a custom-made prosthesis. At our study institution, a CAD/CAM shoulder (Stanmore Implants, Elstree, UK) is often used for these challenging cases as it secures the glenoid shell to the surrounding scapula as well as the deficient glenoid. [26]

HHRH can be a technically demanding procedure especially in cases where exposure is compromised by body habitus or surgical approach, leading to inaccurate identification and sizing of the anatomical neck and placement of an implant that is either too large or mal-aligned. [10] As reported by other studies evaluating the results of revision arthroplasty, all index procedures were undertaken at a different institution and subsequently referred to our high-volume unit. [10] While there is no evidence to suggest that surgical experience influences the outcome following resurfacing arthroplasty, it is likely to be a contributing factor since mal-aligned and/or inappropriately large prostheses were observed in 45% of cases (10 out of 22 shoulders) in this study. [5, 6]

Limitations of this study included its retrospective design, the small sample size, the short follow-up, and the different prostheses used during revision surgery. Nonetheless, this study provides useful information to surgeons carrying out revision surgery for failed humeral head resurfacing.

In conclusion, we have reported the results of revision shoulder arthroplasty for failed humeral head resurfacing hemiarthroplasty. Glenoid erosion was the most common reason for failure and at short-term follow-up there was a significant improvement in both forward elevation and functional outcome. Given the popularity of resurfacing arthroplasty, larger long-term studies are needed to identify factors that increase the likelihood of failure and to establish the longevity of implants used in the revision setting.

Acknowledgements

None

Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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