Shoulder Resurfacing

MINIMUM 20 YEAR FOLLOW-UP

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Abstract

Shoulder resurfacing is an attractive concept because it preserves, rather than removes, the humeral head. With a less invasive surgery there is the promise of better function as well as a less difficult revision if it is later needed. We asked if shoulder resurfacing procedures improved function and had satisfactory implant survival over the long term. 61 patients (74 shoulders) with shoulder resurfacing procedures were followed for a minimum of 20 years. Of these there were 41 total resurfacing procedures and 33 hemiarthroplasties. Seven additional patients were lost to follow-up. The average age at the time of surgery was 58 years. 84% of patients were followed until their death. The humeral component we used consisted of a cup for the surface replacement with a short central peg. The humeral component was placed either with or without cement. The glenoid was resurfaced with a cemented polyethylene or polyurethane component. 95% of patients were satisfied with their result. There were no periprosthetic fractures, dislocations, or infections. Two humeral components were revised to stemmed prostheses—one for loosening and one for unexplained pain. One humeral resurfacing was revised from a cementless to a cemented resurfacing prosthesis. Twelve cemented polyethylene glenoid prostheses had radiolucencies but only three had symptoms requiring revision surgery. Three of four polyurethane glenoid prostheses showed severe wear but none were loose or required revision surgery. Shoulder resurfacing is a successful procedure for most patients over the long term.

Introduction

Most patients with end stage arthritis of the shoulder are treated by total shoulder replacement.5,16,24 This involves removal of the humeral head and insertion of a stem into the medullary space of the humerus. The results are usually quite satisfactory, however, there remain some concerns. Stem supported devices can cause a stress riser or stress shielding effect.17,27 This can lead to periprosthetic fracture or prosthetic loosening.10 Another concern is “pilot error” with insertion of a stemmed device. If the version of a shoulder device is incorrect by just 15° a painful shoulder will be the result.7

Shoulder resurfacing is attractive because it preserves the humeral head. The retained humeral head continues to provide proprioceptive feedback. The resurfaced shoulder is stable and capable of an excellent range of motion. Since the humeral head is retained it is easier to assure correct version, offset and inclination of the prosthesis during surgery. With a limited amount of implanted material, infection if it occurs can be dealt with more easily. Because the humerus is not decapitated, shoulder resurfacing is also a less invasive surgery. There is less pain and blood loss and an easier rehabilitation from resurfacing.
as compared to total shoulder replacement.\textsuperscript{6,11,12}

The first total shoulder resurfacing procedure was performed by Dr. Charles O. Townley in 1958 using a metal humeral component and a polyurethane glenoid (Fig 1). Other investigators later performed shoulder resurfacing procedures using small hip resurfacing prostheses.\textsuperscript{8,23} Zippel was the first to publish a paper describing the use of a metallic surface replacement of the humeral head.\textsuperscript{28} With the advent of stem supported total shoulder prostheses shoulder resurfacing was abandoned with the exception of a few surgeons.

Young patients, in particular, want to keep their bone, enjoy an active lifestyle and don’t want to worry about having a failed intramedullary stem supported shoulder prosthesis. Recently cemented and cementless hemi and total shoulder resurfacing prostheses have again become popular. The results of these procedures at midterm follow-up have been favorable.\textsuperscript{6,12,12,21} It has been suggested, but not proven, that humeral resurfacing prostheses can loosen and fail more commonly over time than stem supported prostheses because they have less fixation area.\textsuperscript{2,8,9} Also, there is fear that humeral neck fractures, or humeral head collapse may occur in a similar fashion as occurs with hip resurfacing.\textsuperscript{19,25}

Our questions are: What are the functional results from shoulder resurfacing surgery? What is the long term survival of shoulder resurfacing prostheses? Finally, what are the complications of shoulder resurfacing procedures over the long term?

\section*{Materials and Methods}

61 patients (74 shoulders) who underwent shoulder resurfacing surgery using the Total Articular Replacement Arthroplasty (TARA) prosthesis from 1958 to 1989 were studied (Fig 2). None of the patients had prior implant arthroplasty, however, 18 patients had undergone prior surgery to treat a fracture, dislocation, impingement syndrome, or a rotator cuff tear. The diagnosis was osteoarthritis in 37 shoulders (50\%), posttraumatic arthritis in 20 shoulders (27\%), inflammatory arthritis in 12 shoulders (16\%), osteonecrosis in five shoulders (7\%)

The indication for surgery in all patients was severe pain associated with limitations in function. All of patients had been treated extensively but unsuccessfully with nonoperative methods. All patients were unwilling to continue to accept their symptoms and opted for surgical treatment even when advised there was no certainty of outcome.

Exclusion criteria were prior infection of the shoulder, insufficient bone stock, and neurologic injuries. There were 41 total resurfacing procedures and 33 hemiarthroplasties. Total arthroplasties were performed when there was significant glenoid erosion present.
The patient population consisted of 32 women and 29 men. The mean age was 58 years (range, 32 to 71 years). All patients were followed until their death or a minimum of 20 years. 84% of patients had died by the time of final follow-up. The mean age at the time of death was 81 years (range, 59 to 92 years) and the mean follow-up was 28 years (range 20 to 41) (Table 1). Institutional Review Board Approval was obtained for this study.

Surgery was performed by two surgeons JWP and COT. A deltopectoral approach was used for all procedures. The subscapularis tendon was opened and the shoulder was dislocated anteriorly by external rotation. The labrum was debrided as necessary and any contractures were released. The humeral head was measured and prepared with a milling device to accept the humeral cup. The humeral prosthesis with the best head coverage was chosen and was placed in anatomic version. An anatomic repair of the subscapularis was performed.

A standard sling was used for 6 weeks postoperatively. Home exercises were started on the first postoperative day and consisted of passive circumduction and pendulums as well as active range of motion exercises such as saws (back and forth motion of the arm in the coronal plan with a flexed elbow). External rotation was allowed to within 30° of that obtained during the surgery, after the subscapularis repair. Patients participated in formal physical therapy or a therapist directed home program for an additional 6 weeks. No limitations were placed on patients’ activity after 3 months. Three of the earliest humeral components were placed without cement using a bolt through the lateral humeral cortex (Fig 3). Thirty additional humeral components were placed without a bolt and without cement and 37 humeral components were cemented in place using polymethylmethacrylate (Simplex, Howmedica, Rutherford, NJ.) Four humeral components were cemented in place using polyurethane cement (Ostamer, William S. Merrell Co., Cincinnati, OH). The glenoid component, when used, was always cemented in place. Polyurethane cement was used for the polyurethane glenoid components but the polyethylene glenoid prostheses were cemented in place using polymethylmethacrylate. The polyethylene glenoid prostheses became available in 1971 and had a central keel (Howmedica, Rutherford NJ, Depuy Orthopaedics, Inc., Warsaw, IN) (Fig 2).

The polyurethane polymer was prepared by mixing the prepolymer with resin and a catalyst at the time of surgery and shaping it in situ or on the back table to the humeral prosthesis. When used the polyurethane acted as both the anchoring cement

Table 1. Survivorship among original patients treated shoulder joint resurfacing.

<table>
<thead>
<tr>
<th>Years Since Surgery</th>
<th>Number (%)</th>
<th>Mean Age at death of follow-up (years; range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients who had died</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>51(84)</td>
<td>81 (59-92)</td>
</tr>
<tr>
<td>5-9 years</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>10-19 years</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>20-30 years</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Longer than 30 years</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Patients alive at follow-up</td>
<td>10(16)</td>
<td>75 (54-94)</td>
</tr>
</tbody>
</table>

Fig. 3 Early hemiresurfacing revised to a total resurfacing prosthesis because of humeral component loosening and glenoid wear.
and the glenoid bearing surface. The humeral prostheses were all made of cobalt chromium (Depuy Orthopaedics, Inc., Warsaw IN; Howmedica, Rutherford, NJ).

Patients were followed prospectively and asked to return at 1 year, 2 years, 5 years and every 5 years thereafter. The functional assessments were made at 2 years. Patients were asked about their activity and specifically whether they were limited. Any limitations were specific to that particular patient’s life goals. Clinical examinations to final follow-up were available for 25 patients (41%). Patients were asked about the need for additional surgery on their shoulder after their resurfacing procedure. If surgery had been performed, the patient was asked to provide information about that procedure. Information about the patient’s shoulder function was obtained from the family for patients who had died.

Postoperative radiographs were assessed for the presence or absence of lucent lines and their width in relation to time. Definite loosening was defined as a change in the position of the component and probable loosening was defined as an unchanged position but progressive radiolucent lines involving all parts of a component. Because radiographs were not standardized (they were made by different technicians using different techniques on different equipment over many years) no specific radiographic measurements were made.

The subjective result after surgery was rated by the patient as “very satisfied”, “satisfied,” “somewhat satisfied”, “somewhat disappointed,” or “very disappointed.”

Results

Most patients experienced little or no pain and only two experienced severe pain. Of the patients assessed for postsurgical activity, 39% participated in strenuous athletics or work and only two were dissatisfied with their function. Ninety-two percent of patients were not limited in their activities (Table 2).

31 patients (36 shoulders) were very satisfied with the result of their shoulder resurfacing procedure. 22 patients (27 shoulders) were satisfied four patients (7 shoulders) were somewhat satisfied and four patients (4 shoulders) patients were somewhat or very disappointed. We were unable to determine a difference in satisfaction or function based on whether the patient had a hemi or total resurfacing procedure.

96% (71 of 74) of the humeral prostheses remained in place without symptoms or need for revision at

<table>
<thead>
<tr>
<th>Pain</th>
<th>Number (%)</th>
<th>Assessed 2 years after procedures</th>
</tr>
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<tbody>
<tr>
<td>No pain</td>
<td>63 (85)</td>
<td></td>
</tr>
<tr>
<td>Slight pain</td>
<td>8 (11)</td>
<td></td>
</tr>
<tr>
<td>Moderate pain</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>Severe pain</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>Function: postsurgical activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly active</td>
<td>29 (39)</td>
<td>Strenuous sports or job</td>
</tr>
<tr>
<td>Active and no limitations necessary</td>
<td>38 (51)</td>
<td></td>
</tr>
<tr>
<td>Moderately active</td>
<td>5 (7)</td>
<td></td>
</tr>
<tr>
<td>Inactive</td>
<td>2 (3)</td>
<td></td>
</tr>
<tr>
<td>Patient satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied with outcome</td>
<td>70 (95)</td>
<td>2 patients were dissatisfied because of limited motion or weakness</td>
</tr>
<tr>
<td>Dissatisfied with outcome</td>
<td>4 (5)</td>
<td>2 patients were dissatisfied because of pain</td>
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</tbody>
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Table 2. Functional results of shoulder joint resurfacing
the time of death or final follow-up. Of the 28 glenoid prostheses available for final review, twelve polyethylene glenoid significant radiolucencies but only four had symptoms (Fig 4). Three of four polyurethane components showed wear through but none loosened or required revision. All four of these patients continued to report a satisfactory outcome. After the polyurethane wore away these shoulders seemed to function as a hemiarthroplasty.

There were no infections, subluxations, or periprosthetic fractures. There were two temporary nerve palsies. One involved the entire brachial plexus and one involved the axillary nerve only.

There were seven revision surgeries. One of the earliest cementless hemiresurfacing components was revised for loosening and glenoid wear (Fig 3). It was revised to a cemented total resurfacing prosthesis. Another hemiarthroplasty was revised to a stem supported hemiarthroplasty for pain. This implant was not loose at the time of revision surgery. One resurfacing humeral prosthesis was placed on an insufficient humeral head and this prosthesis loosened, requiring revision to a stemmed prosthesis (Fig. 5). One hemiarthroplasty was revised to a total resurfacing prosthesis by the addition of a glenoid. Two loose polyethylene glenoid prostheses were removed and one was revised.

**Discussion**

Shoulder resurfacing in our patients achieved its goal of reducing pain, and increasing function. The satisfaction results in this study are as good as or better than those reported using a conventional stemmed humeral prosthesis. The survival of the resurfacing humeral prosthesis is very satisfactory but we found like other authors using total shoulder replacement prostheses that the glenoid component remains vulnerable to wear and loosening over time.

We saw few complications in our patients with shoulder resurfacing. Subluxation and dislocation did not occur and we attribute this to correct sizing and version of the humeral component since the implant was placed on the natural humeral head. Instability is a reported complication with total shoulder replacement. Also, there were no periprosthetic fractures. The lack of stress shielding with resurfacing is possibly the reason. There were two instances of humeral prosthesis loosening requiring revision. One involved a first generation cementless prosthesis attached with a bolt through the lateral humeral cortex. This design was
discontinued after three cases. The other humeral prosthesis that loosened was in a case where the humeral head was deficient. There were no infections.

There are limitations of this study. The case numbers are small but this is consistent with most other reports of shoulder prostheses. Nevertheless, small case numbers suggest caution in interpreting the incidence of uncommon complications such as peri-prosthetic fracture and infection. This study investigates a prosthesis that was in evolution as it was being used. Both cemented and cementless humeral fixation was used but we are unable to draw conclusions on this variable. There were no autopsy retrievals or pathologic specimens.

Other limitations are that the two surgeons involved performed many of the clinical and radiographic analyses. Complete follow-up data (including radiographs) were not available on all of the patients so questionnaires were relied upon for some of the information. The primary outcome, prosthesis survival, is known for all but seven patients who were lost to follow-up. Because this is a single patient series, there is no comparison to stemmed humeral devices.

This is primarily a report on prosthesis survival and functional improvement after shoulder resurfacing. Data on range of motion, specific radiographic measurements, and strength are not presented because of lack of standardization. We did not use specific outcome measurement instruments as none of the commonly used scales were available during most of the time our patients were initially treated.\textsuperscript{3,4,14} We recognize that, although most patients experienced substantial improvement and performed at their individual desired level after surgery, there is no way to standardize this data. We did not find any reason to limit the activity of a patient based on the findings in this study.

The indications for shoulder resurfacing are the same as those for the use of any shoulder prosthesis. Shoulder resurfacing can be used in the treatment of osteoarthritis, rheumatoid arthritis, post dislocation arthritis, and osteonecrosis.\textsuperscript{5,11,12} There are limitations to resurfacing. If there is not enough humeral head remaining then a stemmed device is needed (Fig 5). We find that 70\% of the humeral head remaining is enough.

One of the advantages of resurfacing is that no bone stock is lost. If there were an infection or instability, the joint is amenable to arthrodesis. This is not the case after stemmed shoulder prostheses. Total shoulder resurfacing is more technically demanding than total shoulder replacement as access for preparation of the glenoid is more difficult without removing the humeral head.

Shoulder resurfacing may be more successful than hip resurfacing.\textsuperscript{19,25} There are several differences between shoulder and hip resurfacing. The applied loads are much less on the shoulder. The shoulder joint has a much reduced offset compared to the hip. Shoulder prostheses have a greater radius of curvature. The shoulder joint is much less constrained compared to the hip. Soft tissues may be more critical to function for the shoulder as compared to the hip.

Contemporary shoulder resurfacing began again in 1986 with a cementless hydroxyapatite prosthesis. The revision rate for this humeral prosthesis is 1-2\%. When glenoid resurfacing is performed loosening occurs in up to 10\% of patients. 95\% of patient report a satisfactory functional outcome.\textsuperscript{6,11,12,21}

The favorable results of shoulder resurfacing are no doubt partially due to the ability to obtain correct version, inclination, offset and size. These factors are easily judged and relate directly to the anatomy. For most surgeons, the skills of shoulder replacement are learned from fracture care of the occasional shoulder replacement procedure. In fracture and replacement cases the humeral head has been removed and version is estimated either indirectly or from guides during surgery.
Most shoulder prostheses are placed by surgeons who do only a few procedures a year. 30 percent of unsatisfactory results after shoulder replacement are due to component malposition.7

Resurfacing arthroplasty is a different procedure than shoulder replacement. With stemmed implants the position of the prosthetic humeral head, to a significant degree, is determined by the relationship of the stem to the humeral shaft.27 Some of the newer modular total shoulder prostheses attempt to more closely duplicate natural shoulder anatomy but long term results on these implants are not yet available. For resurfacing, the prosthetic head is placed on the natural humeral head (Fig. 6). In patients with severe arthritis and glenoid erosion the humeral head may have become medialized and correcting this fully with a stem supported total shoulder replacement may result in enough lateralization that stiffness and pain occurs postoperatively. With resurfacing there is usually less lateralization (Fig 7).

The long-term debate over whether a total or hemiarthroplasty procedure is best is not solved with our work. In stemmed total shoulder replacement the rate of conversion from a hemiarthroplasty to a total shoulder replacement is up to 12%. The conversion rate may be less with resurfacing. We attribute at least some of the success of our hemiresurfacing procedures to releasing soft tissue contractures and restoring the normal humeral contours. This likely improves the kinematics of shoulder function. Since the version and spacing of the joint are improved less subsequent glenoid pain and wear may result. This may suggest performing a hemiarthroplasty in many cases.5, 6, 11, 12

Total shoulder resurfacing is a valid procedure and like total shoulder replacement will result in excellent pain relief and function. The problem of glenoid loosening remains. The difficulties with total shoulder resurfacing are primarily on the glenoid side. Well performed humeral resurfacing rarely fails over time. This is true with or without the use of cement.

Polyurethane as a bearing surface may significantly improve the future results of glenoid resurfacing. Compared to polyethylene, polyurethane has lower frictional properties. Polyurethane surfaces are easier to lubricate because they are hydrophilic while polyethylene is hydrophobic. Polyurethane wear debris does not cause osteolysis and bone loss. The modulus of elasticity of polyurethane can be made similar to cartilage, unlike polyethylene which is

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Fig. 6  Axillary view of humeral resurfacing prosthesis showing anatomic positioning.

Fig. 7  20 year result of resurfacing prosthesis performed for post dislocation arthritis. The center of rotation suggests correct lateralization.
about 70 times stiffer. Polyurethane has been selected for several orthopedic applications such as the artificial cervical disk. The polyurethane used in our early cases was very crude compared to what is available today.1,13,22,26

The options available for glenoid fixation are improving. For cementless applications we are currently using trabecular metal backed polyethylene glenoid prostheses as we continue to work on our polyurethane bearing surface.

Shoulder resurfacing is an attractive option for treating shoulder arthritis. It works well, is bone conserving and avoids the concerns of a stem supported prosthesis. There are more salvage options if there is a failure.

References