Cementless Humeral Resurfacing Arthroplasty in Active Patients Less Than Fifty-five Years of Age

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Background: Cementless humeral resurfacing arthroplasty is a bone-conserving arthroplasty option for patients with glenohumeral arthritis. It has been successful in the older patient population. However, data regarding the results of arthroplasty in younger, more active patients are lacking. We report the two-year results of this procedure in active patients who were less than fifty-five years of age.

Methods: We reviewed prospectively collected clinical data on a series of thirty-six patients under fifty-five years of age with end-stage glenohumeral arthrosis, but without osteonecrosis, who had undergone a cementless humeral resurfacing hemiarthroplasty performed by a single surgeon. All patients were followed for a minimum of two years. We assessed pain, function, and patient satisfaction and documented all complications. Radiographs were evaluated for implant loosening.

Results: The thirty-six patients had a mean age of 42.3 years and were followed for a mean of 38.1 months. Scores measured with a visual analog pain scale, the Single Assessment Numeric Evaluation (SANE) scale, and the American Shoulder and Elbow Surgeons (ASES) scale all improved significantly from preoperatively to two years postoperatively (p < 0.001). Complications included one traumatic subscapularis rupture at six weeks, three cases of arthrofibrosis, and one deep hematoma. No obvious radiographic evidence of loosening was noted at the time of the latest follow-up. One shoulder was converted to a stemmed total shoulder arthroplasty at twenty-four months because of pain, but the implant was not loose at the revision. The remaining thirty-five patients were satisfied with the outcome at the time of the latest follow-up and had returned to their desired activity.

Conclusions: Cementless humeral resurfacing arthroplasty is a viable treatment option for younger, active patients. Early results indicate that the desired function and pain relief can be expected. Implant loosening and glenoid wear do not appear to be concerns in the short term despite the high activity levels of many patients. Long-term follow-up is needed to determine if these results persist.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Currently, glenohumeral osteoarthritis in younger, active patients is a condition without an ideal solution. These patients desire a treatment that will provide pain relief and restore their ability to perform activities of daily living but also, in some cases, that will enable them to return to sports participation. When nonoperative measures fail, arthroplasty may be considered. However, it is not well understood which activities can be performed without affecting the life span of the implant. This is particularly true for cemented glenoid components, which are known to loosen in up to 39% of patients by the time of mid-term to long-term follow-up. In addition, active patients participating in collision sports have a theoretical risk of...
sustaining a periprosthetic fracture of the humeral shaft, which may be difficult to treat in a patient with a stemmed implant.

As early as 1980, humeral head resurfacing was proposed as a treatment for glenohumeral arthrosis in an attempt to preserve the original anatomy and avoid humeral head resection by using an uncemented surface replacement with a central peg. Preservation of the humeral head allowed the native inclination, offset, head-shaft angle, and version of the humerus to be maintained, facilitating later revision to a conventional total shoulder arthroplasty if needed.

There is limited available information regarding the results of arthroplasty in younger patients. The primary purpose of this study was to report the results of cementless humeral resurfacing arthroplasty in a consecutive series of patients who were younger than fifty-five years of age.

**Materials and Methods**

From 2001 to 2004, the senior author (D.S.B.) performed 287 shoulder arthroplasties in patients with symptomatic end-stage glenohumeral arthrosis. Of these, thirty-eight consecutive patients were younger than fifty-five years of age and were treated with a cementless humeral resurfacing arthroplasty (Copeland Mark-2, MacroBond; Biomet, Warsaw, Indiana); they were included in this study. Patients with radiographic evidence of osteonecrosis, with or without any degree of head collapse, were not considered candidates for this procedure because of our concern that the cementless humeral resurfacing arthroplasty might not address bone pain or structural abnormalities of the humeral head in a patient with osteonecrosis. Two patients were lost to follow-up.

Conservative treatment, including physical therapy, intra-articular injections (corticosteroids and/or hyaluronic acid), and/or arthroscopic débridement, had failed for all patients. The age of fifty-five years or less was chosen because of the typical high level of activity of this patient population in our community as well as reports in the literature that suggest possible problems with traditional arthroplasty in this age group. In addition, we have had experience with younger patients requesting a treatment that may allow them to return to athletic activity. Many patients in this series had previously been told by other medical providers that no options other than conservative treatment were available.

This study was approved by our institutional review board, and all enrolled patients provided informed consent to undergo the surgical procedure and follow-up examinations, including completion of the rating instruments used in this investigation. Treatment options other than cementless humeral resurfacing arthroplasty, including total shoulder replacement and humeral head replacement with or without biologic resurfacing of the glenoid, had been discussed with the patients. After 2003, some of these patients were also enrolled in a simultaneous multicenter, prospective study of cementless humeral resurfacing arthroplasty in which no patient age or pathological conditions were specifically excluded.

Data collected included the suspected etiology of the arthrosis, the visual analog pain score (marked on a 10-cm line, with 0 indicating “no pain” and 10, “worst pain ever”), the Single Assessment Numeric Evaluation (SANE) score, the American Shoulder and Elbow Surgeons Score (ASES), stability, and patient satisfaction. The SANE and ASES are validated scoring measures and have been described elsewhere. Routine anteroposterior and axillary lateral radiographs were made preoperatively, at the first postoperative visit, at six months, at one year, and then annually thereafter. They were evaluated for loosening, determined by the presence of implant migration or progression of radiolucent lines around the implant. Because radiographs were not standardized (they were made with different techniques and by different technicians as the patients were not always seen at the same office), the degree of glenoid erosion, the glenohumeral relationship, and the acromiohumeral relationship were all evaluated with gross observation of the radiographs only (i.e., no specific measurements were made). Glenoid wear patterns were classified on the basis of the criteria described by Walch et al.

**Surgical Procedure (Figs. 1-A through 1-D)**

All surgical procedures were performed by the same surgeon in an outpatient surgical center, with the patient discharged on either the same day or the following morning, depending on his or her desire to stay overnight. All patients were treated with a cementless humeral resurfacing arthroplasty that was performed by the senior author (D.S.B.) with use of the Biomet Copeland Mark-2 MacroBond implant. A first-generation cephalosporin was administered intravenously thirty to sixty minutes prior to the incision. Clindamycin was used for patients with a known allergy to cephalosporins. A general anesthetic in conjunction with a preoperative interscalene block was used for all patients. The patient was placed in a semi-reclined position with the arm draped free.

A deltopectoral approach was used, with preservation of the pectoralis major tendon and the circumflex humeral vessels. Aggressive soft-tissue releases of the subscapularis and the anterior and inferior aspects of the capsule were performed when necessary to improve tendon excursion. These included a 360° release of the subscapularis tendon (the coracohumeral ligament and the rotator interval, the inferior aspect of the capsule, the anterior aspect of the capsule, and any anterior subcoracoid adhesions). The anterior aspect of the capsule was left attached to the subscapularis to enhance suture fixation of the tendon back to its stump on the lesser tuberosity. Posterior capsular plication was not performed, and excessive posterior laxity after implant placement and subscapularis repair was eliminated with closure of the rotator interval.

Tenodesis of the long head of the biceps was done routinely in all patients, as prior to this study we had observed recalcitrant biceps tenosynovitis after arthroplasty in more active patients. The biceps was repaired with nonabsorbable suture to the surrounding rotator cuff tissue at its entrance into the joint at the end of the procedure. The intra-articular portion of the biceps tendon was released from the superior aspect of the labrum and was excised.

The cementless humeral resurfacing arthroplasty was performed with use of the previously described technique.
The most appropriately sized implant was chosen and was placed with respect for anatomic version and inclination, which varied among patients. Specifically, the implant that provided the best head coverage was chosen. When the ideal size appeared to be between available options, the smaller size was chosen to prevent “overstuffing” of the joint. Cement was not used; autogenous or allograft cancellous bone was utilized to fill minor humeral head defects. No patient was treated with structural grafting.

The glenoid was treated in some patients, if clinically indicated at the time of the surgery and on the basis of radiographic findings (eccentricity of the glenoid and/or cystic changes). No glenoid replacements were used regardless of the glenoid type, but biologic resurfacing with a meniscal allograft or human dermis allograft (GraftJacket; Wright Medical Technology, Arlington, Tennessee) or microfracture (for focal, contained chondral defects) was performed in some patients. When there was eccentric absence of articular cartilage, the remaining cartilage was débrided manually to restore the glenoid surface to a more symmetric concavity and to restore version of the glenoid. In addition, contained cystic glenoid defects were filled with allograft cancellous bone when they were >5 mm in diameter. When this was performed, the defect was covered with human dermal allograft to keep the graft in place. Full-thickness rotator cuff tears were repaired with use of suture anchors, but partial tears, subacromial impingement, and arthritis of the acromioclavicular joint were not addressed. Finally, degenerative labral tears were débrided to a stable rim prior to placement of the implant. An anatomic repair of the subscapularis, without medialization or z-lengthening, was always performed regardless of the preoperative range of external rotation. Suture anchor repair was employed along the lesser tuberosity when the subscapularis tendon grossly appeared thinner laterally or when we used an implant that seemed to rest near the insertion after impaction, as the latter may jeopardize the tendon insertion. The deltopectoral interval, subcutaneous tissues, and skin were all closed with absorbable sutures. No drains were used.

Fig. 1-A
Preoperative axillary radiograph of a forty-seven-year-old man, made twenty years after anterior coracoid transfer for the treatment of shoulder instability, demonstrating intra-articular screw penetration and posttraumatic degenerative arthritis.
A standard sling or SlingShot pillow sling (BREG, Vista, California) was used for up to six weeks. Home exercises were started on the first postoperative day and included passive circumduction and pendulums as well as active range-of-motion exercises such as saws (back and forth movement of the arm in the coronal plane with a flexed elbow) and tummy rubs (back and forth movement across the abdomen in the coronal plane) with the shoulder in up to 20° to 30° of elevation. External rotation was allowed to within 30° of that obtained during the surgery, after the subscapularis repair.

Fig. 1-B
Extensive humeral head damage and defects were seen intraoperatively.

Fig. 1-C
The cementless humeral resurfacing arthroplasty implant is in place.
Formal physical therapy was started after the first postoperative office visit, between ten and fourteen days following the surgery, and was continued for three months. A standardized rehabilitation program was followed with use of precautions to protect the subscapularis for the initial six weeks. This involved limitations of active internal rotation resistance, and external rotation motion was limited to within 30° of the maximal external rotation obtained during the surgery after subscapularis repair.

Statistical Methods
Paired t tests were used to test for differences between the preoperative and two-year postoperative mean scores measured with the outcome rating scales. Significance was set at the 0.001 level with use of a Bonferroni adjustment.

Results
Thirty-eight patients who were less than fifty-five years of age were treated by the senior one of us between 2001 and 2004. Two patients were lost to follow-up. Thus, thirty-six patients followed for a minimum of two years were available for this study. The mean age at the time of the operation was 42.3 years (range, twenty-eight to fifty-four years), and the latest follow-up evaluation was at a mean of 38.1 months (range, twenty-four to sixty months). The proposed etiology of the arthrosis was posttraumatic in three patients, post-instability/stabilization in seven, chondrolysis after recent prior surgery in three, and idiopathic or microtraumatic in twenty-three. Three patients underwent cancellous bone-grafting combined with biologic resurfacing with GraftJacket to treat a contained glenoid defect resulting from loosening of screw fixation that had been used for a prior coracoid transfer. One patient received a lateral meniscal allograft to treat posterior instability and a deficient labrum. Two patients underwent microfracture of small (<1-cm) chondral defects of the glenoid, and eighteen had manual débridement of articular cartilage, but not reaming, to restore uniform concavity to the glenoid fossa. In the eight patients who appeared to have an early, type-B1, glenoid wear pattern according to the system of Walch et al., the residual articular cartilage anteriorly was débrided down to subchondral bone, and any small central ridge, if present, was flattened with use of a high-speed burr. This grossly restored glenoid version as there was no apparent osseous deficit or erosion. Two shoulders in which the anterior articular surface was absent and the posterior surface was intact were treated in a similar manner. In these cases, care was taken to not penetrate deep into the supporting subchondral bone and only enough bone was removed to restore the gross uniform concave appearance of the glenoid fossa.

Four patients had simultaneous repair of isolated rotator cuff tears, which ranged in size from 1 to 4 cm. Eleven patients had pathological involvement of the long head of the biceps, including partial tears, SLAP tears involving the insertion, hypertrophic tenosynovitis, and loose bodies in the bicipital groove. As mentioned, all patients, even those without pathological involvement of the biceps tendon, underwent a biceps tenodesis.

There were no major intraoperative complications such as neurovascular injury, infection, fracture, or gross malpositioning of the implants. A deep hematoma developed in one patient and was evacuated at three weeks after the surgery. In one patient, who had had multiple previous operations on the shoulder, the subscapularis repair ruptured at four weeks, when he lifted a heavy object overhead. Three weeks later, he underwent subscapularis repair with suture anchors and allograft augmentation. Arthrofibrosis (defined as substantial functional loss of motion not responsive to rehabilitation for three months) developed in three patients. Arthroscopic débridement and selective capsular release in order to restore at least 90° of external rotation in the 90° abducted position was successful in all three patients. Two of these cases of arthrofibrosis were associated with a preoperative diagnosis of chondrolysis and capsular thickening.

Preoperatively, gross evaluation of the radiographs demonstrated a concentric glenohumeral relationship in twenty-eight patients (Walch type A1 in twenty-six and type A2 in two), minimal posterior subluxation (<33% as determined with gross observation; Walch type B1) in eight, and no cases of an advanced biconcave glenoid (Walch type B2). However, two patients who had a B1 classification radiographically showed, at the time of surgery, some very early signs of biconcavity with...
TABLE I Results of Outcome Rating Scores Following Cementless Humer al Resurfacing Arthroplasty*

<table>
<thead>
<tr>
<th>Score</th>
<th>Preoperative</th>
<th>At Two Years</th>
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<tbody>
<tr>
<td>Visual analog pain scale</td>
<td>7.5 ± 1.7</td>
<td>1.3 ± 0.6</td>
</tr>
<tr>
<td>Single Assessment Numeric Evaluation (SANE)</td>
<td>24.7 ± 9.2</td>
<td>90.4 ± 4.7</td>
</tr>
<tr>
<td>American Shoulder and Elbow Surgeons (ASES)</td>
<td>29.8 ± 11.1</td>
<td>87.7 ± 12.6</td>
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*The values are given, in points, as the mean and standard deviation.

Discussion

We report the results of cementless humeral resurfacing arthroplasty with a Biomet Copeland Mark-2 implant in thirty-six patients, younger than fifty-five years old, who were treated between 2001 and 2004 and were followed pro-

spectively for a minimum of two years (average, 38.1 months). We found substantial patient satisfaction, a perceived return of function, and decreased pain with neither gross loosening nor radiolucent lines around the humeral implant.

Cementless humeral resurfacing arthroplasty with use of this implant has previously been reported to be successful in patients with many forms of glenohumeral disease at a mean age of 73.4 years. Initially placed in conjunction with a glenoid component, this implant has been shown to be beneficial even when used as a humeral head replacement alone. Although the rate of loosening has been reported to be lower with use of hydroxyapatite-coated implants, our experience with the MacroBond prosthesis has been satisfactory.

Although there were some complications in our series, all have been reported in association with the standard surgical technique for any shoulder replacement and were not specific to this humeral resurfacing prosthetic design. In fact, our overall complication rate with cementless humeral resurfacing arthroplasty was lower than that reported in association with stemmed prosthesis. Our one patient who underwent revision to a total shoulder arthroplasty did not have substantial improvement even after the revision, indicating a possible unidentified etiology of the pain. However, other authors have suggested that conversion of even a stemmed humeral head replacement to a total shoulder arthroplasty does not yield high satisfaction rates.

In younger patients with more advanced stages of gleno-

humeral arthrosis, arthroscopic treatment yields poor results, similar to those obtained in nonathletic patients. Generally, there seems to be a consensus regarding the limited effectiveness of arthroscopic chondral débridement in patients with established glenohumeral arthritis. Brislin et al. reported a surgical technique involving use of a porcine xenograft patch on the glenoid in young patients with glenohumeral arthro-

sis. Preliminary results regarding pain relief and improve-

ment of the range of motion in ten young patients were good. The results of that study have not yet been reproduced in larger numbers of patients over a substantial length of time. Furthermore, limited studies of biologic glenoid resurfacing with use of other materials have shown some promising, albeit short-term, results.

Glenohumeral arthodesis is an option for young patients with advanced arthritis, as it offers a definitive solution without the complications associated with replacement. However, once informed about the resulting functional restrictions, young pa-

tients often prefer procedures that allow joint mobility.

The definitive option for the treatment of glenohumeral arthrosis remains shoulder arthroplasty. Usually, it is indicated when the patient’s quality of life has not been improved by previously described alternatives. Humeral head replacement and total shoulder arthroplasty are traditional options for patients with advanced arthrosis. It was not the purpose of this study to compare these two procedures. At present, no overall consensus has been reached favoring one over the other, and this study does not offer any conclusions that help to determine this issue.
We presently recommend modification of sports activity to our young, active patients who have undergone shoulder arthroplasty, regardless of the type of implant that was used. Although we do not necessarily advocate specific “do’s and don’ts,” we recommend that patients be educated regarding the potential negative impact that rigorous physical activity, especially collision sports, may have on the longevity of the implant and the need for additional surgery; however, definitive data are not presently available. On the basis of an opinion survey of the members of the ASES, Healy et al. provided guidelines for returning to sports activity following shoulder arthroplasty. However, specific indications and a data-driven algorithm for the return to sports activity are not presently available.

Sperling et al. reported the results of humeral head replacement and Neer total shoulder arthroplasty in patients with glenohumeral arthritis who were younger than fifty years of age. Follow-up at fifteen years confirmed pain relief and improvement in motion after both procedures. The rates of survival of the humeral head replacements were 82% at ten years and 75% at twenty years, and the rates of survival of the total shoulder replacements were 97% and 84%, respectively. However, use of a modified Neer outcome rating system to assess the patients’ daily performance ability showed unsatisfactory results in 60% of those who had undergone humeral head replacement and in 48% of those who had undergone total shoulder arthroplasty. Although we recognize our lack of a comparable control group, a major limitation of our study, we think that the substantial improvement in terms of pain relief and function in this challenging patient population demonstrates that cementless humeral resurfacing arthroplasty, without glenoid prosthetic replacement, is an acceptable option.

We attribute the achievement of a concentric position of the humerus as seen on postoperative radiographs, even in patients in whom a slightly eccentric glenoid-wear pattern had been demonstrated preoperatively, primarily to three factors. First, we performed an aggressive soft-tissue release (anteriorly and inferiorly) without subscapularis lengthening in order to restore motion. The release theoretically improves subscapularis excursion postoperatively and, without tendon lengthening, may improve subscapularis strength. This may in turn help to reduce the posterior vector forces caused by an anterior soft-tissue contracture, and we think that such forces are an important factor contributing to progressive posterior glenoid wear. In addition, any abnormal glenoid version in this patient group appeared to be related to asymmetric patterns of wear of the articular cartilage and not to true glenoid bone erosion. This allowed us to restore “apparent version” by removing any residual articular cartilage, thus returning the functional glenoid version to a nearly anatomic status in any given patient. Finally, according to Walch et al., a type-B1 glenoid may become worse with age and may transition to type B2 over time; thus, since our patients were younger, it is possible that a severe, type-B2 pattern had not yet had time to develop. We postulate that restoration of version with preservation of the supporting subchondral bone (i.e., not reaming to cancellous bone) in patients of a younger age may potentially restore more symmetric forces on the glenoid and delay the development of eccentric glenoid wear. We think that, to accomplish this, an anatomic reconstruction involving both bone and soft tissue should be performed. This can be accomplished with either a cementless humeral resurfacing arthroplasty or with an anatomic stemmed hemiarthroplasty. We chose cementless humeral resurfacing arthroplasty without glenoid prosthetic replacement for our patients, although this study does not allow direct comparison of resurfacing arthroplasty with a stemmed implant design in this patient group. Clearly, we will not know the answer to this question until longer-term data can be evaluated.

We did not routinely resurface the glenoid in these cases. Meniscal allograft was used in only one patient because of our experience with three cases, referred to the senior author, in which a meniscal allograft had been placed on the glenoid without evidence of instability and the outcome was a stiff, painful shoulder with a displaced bucket-handle tear of the allograft found at the time of arthroscopic débridement.

GraftJacket human dermal allograft was used in three patients in this series. We utilized this material because it was readily available at our institution. In addition, we had determined intraoperatively that cancellous bone-grafting of substantial glenoid defects was required, and this material seemed to hold the graft in place. It held sutures well and was easily trimmed to fit in situ.

This study had several limitations. Although the patients were enrolled prospectively, there was no control group treated with stemmed arthroplasty (hemiarthroplasty or total shoulder arthroplasty) for comparison. Therefore, we cannot conclude that cementless humeral resurfacing arthroplasty is better than other arthroplasty methods for young patients. Furthermore, this is primarily a report on functional improvement after cementless humeral resurfacing arthroplasty; data on range of motion, specific radiographic measurements, and strength are not presented because of a lack of standardization. However, it is encouraging that thirty of the thirty-six patients were able to participate in their desired level of activity after cementless humeral resurfacing arthroplasty. We did not use a specific outcomes measure of sports activity, as the initial goal of this study was to simply evaluate the overall outcome and patient satisfaction following cementless humeral resurfacing arthroplasty. We did not use a specific outcomes measure of sports activity, as the initial goal of this study was to simply evaluate the overall outcome and patient satisfaction following cementless humeral resurfacing arthroplasty. We did not use a specific outcomes measure of sports activity, as the initial goal of this study was to simply evaluate the overall outcome and patient satisfaction following cementless humeral resurfacing arthroplasty. We did not use a specific outcomes measure of sports activity, as the initial goal of this study was to simply evaluate the overall outcome and patient satisfaction following cementless humeral resurfacing arthroplasty.
longevity of this implant in highly active patients. In addition, the concern over progressive glenoid erosion and the outcomes of revision to a more standard arthroplasty remains substantial. Furthermore, our experience has indicated that many of these patients do not adhere to recommended activity restrictions. They often choose their level of sports participation on the basis of the pain that they experience and their ability to perform at a level that they individually deem to be acceptable. In this group, whose goal is to return to a “more normal” lifestyle as defined by them, cementless humeral resurfacing arthroplasty appears to be a viable alternative to other standard treatments at least in the short term. The patients who were enrolled in this study would not consider doing nothing as an option and had obtained unsatisfactory results from conservative treatment. It remains to be seen whether cementless humeral resurfacing arthroplasty is truly a better option. A prospective, randomized, long-term study comparing cementless humeral resurfacing arthroplasty with a stemmed humeral head replacement and total shoulder arthroplasty in this patient population is required in order to answer that question.

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