Arthroscopic Glenoid Resurfacing as a Surgical Treatment for Glenohumeral Arthritis in the Young Patient: Midterm Results

Felix H. Savoie III, M.D., Kenneth J. Brislin, M.D., and David Argo, M.D.

Purpose: This study investigates the hypothesis that arthroscopic biologic glenoid resurfacing without humeral head replacement will provide results similar to humeral hemiarthroplasty in patients aged under 60 years. **Methods:** Twenty-three consecutive patients aged 15 to 58 years (mean, 32 years) with severe glenohumeral arthritis were prospectively treated with arthroscopic resurfacing of the glenoid with a biologic patch (Restore; DePuy Orthopaedics, Warsaw, IN). Three patients left the study, leaving twenty patients to complete the study. Data collected preoperatively and postoperatively included active and passive range of motion and American Shoulder and Elbow Surgeons (ASES); Constant-Murley; Rowe; University of California, Los Angeles (UCLA); Short Form 12 (SF-12); and visual analog scale (VAS) pain scores. All patients had preoperative and postoperative imaging, either computed tomography scan (n = 2) or magnetic resonance imaging (n = 18), and were re-examined 3 to 6 years after surgery. **Results:** At last follow-up, 15 patients (75%) remained satisfied. Five patients had proceeded to have surface replacement arthroplasty, but four of five said that they would undergo the arthroscopic procedure again. Active and passive range of motion improved in flexion (80° to 150°), abduction (60° to 120°), external rotation with the arm at the side (10° to 30°), external rotation in abduction (30° to 70°), and internal rotation (10° to 50°). Each rating scale used showed statistically significant ($P < .05$) improvement from preoperatively to postoperatively: VAS, from 8 to 2; ASES, from 22 (out of 100) to 78; UCLA, from 15 (out of 35) to 29; Rowe, from 55 (out of 100) to 81; and Constant-Murley, from 26 to 79. Six of eight parameters on the SF-12 also showed statistically significant improvements. **Conclusions:** Glenoid resurfacing with the Restore patch provided statistically significant improvements for young patients with severe glenohumeral arthritis as measured by the VAS, ASES, UCLA, Rowe, Constant-Murley, and SF-12 scores at 3 to 6 years of follow-up. **Level of Evidence:** Level IV, prospective case series investigating the effect of arthroscopic resurfacing rather than shoulder humeral hemiarthroplasty for grade IV arthritis of the glenohumeral joint. **Key Words:** Glenoid resurfacing—Arthroscopy—Shoulder—Arthritis.

Osteoarthritis of the shoulder in the "young" patient may prove to be quite a dilemma. In patients with recalcitrant degenerative disease of the shoulder in whom nonoperative treatment fails, total shoulder arthroplasty has been the gold standard to alleviate pain and improve function.[1] Not all patients with primary or secondary glenohumeral arthritis are ideal candidates for total shoulder replacement, because of age, activity level, or associated pathology. Sperling et al.[1] reported that most patients aged under 50 years had long-term pain relief and improved motion after either hemiarthroplasty or total shoulder arthroplasty. However, when a standard rating system was applied to these patients, more than half had an unsatisfactory result.

In these young patients the choice of replacement has also generated controversy. Studies in older patients have shown a better result after total shoulder arthroplasty compared with hemiarthroplasty with regard to motion, pain relief, and the need for early

From the Department of Orthopaedic Surgery, Tulane University (F.H.S.), New Orleans, Louisiana; OAA Orthopaedic Specialists (K.J.B.), Allentown, Pennsylvania; and Beacon Orthopaedics & Sports Medicine (D.A.), Cincinnati, Ohio, U.S.A.

The authors report no conflict of interest. Financial support was provided by a Mississippi Sports Medicine fellowship and consultant fees from Smith & Nephew and Mitek.

Received May 15, 2008; accepted February 23, 2009.

Address correspondence and reprint requests to Felix H. Savoie III, M.D., Department of Orthopaedic Surgery, Tulane University School of Medicine, 1430 Tulane Ave, SL-32, New Orleans, LA 70112, U.S.A. E-mail: FSavoie@tulane.edu

0749-8063/09/2508-8267$36.00/0
doi:10.1016/j.arthro.2009.02.018

revision surgery.[1-5] However, in these young, active patients glenoid loosening, eccentric wear of the prosthetic glenoid, and the potential need for multiple revision surgeries has led many authors to recommend only humeral head replacement as the initial surgery.[1-4] Burkhead and colleagues[6,7] addressed these concerns in their report of a technique of humeral head replacement with biologic resurfacing of the glenoid with a soft-tissue graft. Their results in 6 patients with 2 years' follow-up showed excellent results in 5 and a good result in 1.[6] Krishnan et al.[7] recently published their results with 2 to 15 years' follow-up in 36 shoulders in 34 patients treated with biologic glenoid resurfacing; 31 of 36 achieved satisfactory results.

The successful results of Burkhead and colleagues[6,7] with allograft resurfacing and the concerns about loosening of the glenoid in young active patients led us to begin to work on an arthroscopic version of hemiarthroplasty. The goal was to obtain an arthroscopic and biologic solution that would preserve the bone structure of the glenohumeral joint and delay the need for replacement surgery. We chose to investigate the use of the Restore patch (DePuy Orthopaedics, Warsaw, IN), an implant made of porcine small intestine submucosa cells that were postulated to have pluripotent properties, in the hope of regenerating viable chondrocytes and a matrix of hyaline cartilage on the articular surface of the glenoid. In 2002 we began a prospective study of an all-arthroscopic technique for biologic glenoid coverage as an intermediate step in the management of glenohumeral arthritis.

This prospective study was designed to evaluate the hypothesis that biologic glenoid resurfacing with the Restore patch will provide results equal to those of humeral hemiarthroplasty in patients aged younger than 60 years with grade IV arthritis of the glenohumeral joint.

METHODS

Twenty-three patients were enrolled in the study between January 2002 and July 2004. All patients considered for the study were at the point of scheduling shoulder replacement surgery. Inclusion criteria included age less than 60 years, grade IV degenerative changes of the shoulder, failure of nonoperative measures, and a willingness to undergo the index procedure. Exclusion criteria were age greater than 60 years, anatomic insufficiency of the glenoid anatomy such that bone grafting would be necessary to restore glenoid congruence, an unwillingness to undergo the index procedure, or an unwillingness to complete the postoperative questionnaire and participate in examinations and postoperative magnetic resonance imaging (MRI) at regular intervals. Patients who declined to be enrolled in the study were treated with either surface replacement arthroplasty, humeral hemiarthroplasty, or total shoulder arthroplasty depending on a variety of factors. During the time frame of this study, approximately 280 shoulder replacements were performed by the senior author. Of these 280, approximately 80 also met the criteria for inclusion in the study, although we did not specifically document their refusal or the reason for this refusal.

Of the patients initially enrolled, 3 were eliminated for reasons of severe and sudden psychiatric illness (1), severe physical illness unrelated to the shoulder (1), and patient's decision (1) and are not included in these data. Preoperative data collected included age, hand dominance, active and passive motion, visual analog scale (VAS) pain level, and the following rating scales: American Shoulder and Elbow Surgeons (ASES); Constant-Murley; Rowe; modified University of California, Los Angeles (UCLA); and Short Form 12 (SF-12).[8-13]

The mean patient age was 32 years (range, 15 to 58 years). There were 13 right shoulders and 7 left shoulders. The dominant extremity was involved in 12 and the nondominant extremity in 8. The mean initial range of motion was as follows: flexion, 80° active and 120° passive; abduction, 60° active and 90° passive; external rotation with the arm at the side, 10° active and 20° passive; external rotation in abduction, 30°; and internal rotation in abduction, 10°. On initial radiographs, there were grade IV arthritic changes, with bone contacting bone on the axillary view in all cases. The degree of degenerative change was also measured on preoperative MRI or computed tomography (CT), or both, as grade IV in all cases.

Preoperative management included 1 or more steroid injections in all patients (range, 1 to 6; mean, 2.8), physical therapy for 3 weeks or more in all patients (range, 3 to 24 weeks; mean, 6.5 weeks), oral glucosamine and chondroitin sulfate in all patients, and intra-articular injection of a variety of non–Food and Drug Administration–approved joint lubrication substances in all patients. All patients underwent MRI, magnetic resonance arthrography, or CT arthrography (2) before surgical intervention. Of the patients, 12 had previous surgery, including diagnostic arthroscopy (1), arthroscopic reconstruction or labral repair (6), arthroscopic debridement (1), and arthroscopic decompression (4). The etiology of the arthritis was thought to be post-traumatic in 4, primary degenera-

tive arthritis in 10 (with 5 of these thought to be a result of posterior subluxation and glenoid retroversion), and chondrolysis in 6. In the 5 patients with posterior subluxation, it was grade II (50%) in 3 patients and grade III (90%) in 2 patients. Glenoid retroversion was measured as 5° in 2 patients and 10° in 3 patients. Preoperative planning in these patients suggested that coplaning with resection of 3 to 8 mm of the anterior glenoid would restore normal glenoid version as compared with the opposite shoulder. In the chondrolysis group, the etiology was unclear. None of the patients had the use of an intra-articular pain pump and only one had the use of a thermal device during the initial surgery. One patient had a repair of a small labral tear by use of Panacryl suture (J & J Ethicon, Somerville, NJ), one had a simple diagnostic arthroscopy, one related the onset of symptoms to a motor vehicle accident 6 months previously, and in the other two there were no discernable risk factors other than arthroscopic surgery noted.

The preoperative evaluations showed a mean ASES score of 22, UCLA score of 15, Rowe score of 55, and Constant-Murley score of 26. The mean preoperative scores on the SF-12 were as follows: physical functioning, 47; role-physical, 41; bodily pain, 27; general health, 72; vitality, 46; social functioning, 54; role-emotional, 76, and mental health, 64. The mean preoperative score on the VAS pain scale was 8 on a scale ranging from 0 to 10 (Table 1).

Method of Postoperative Evaluation

All patients had a physical examination and imaging studies 1 year or more postoperatively to ascertain the presence or absence of the interposition graft and to attempt to quantify any new joint surface. All patients were again re-evaluated 3 to 6 years postoperatively or until the point of failure and additional humeral head replacement. Of the 20 patients, 18 were re-examined in our office; the remaining 2 patients were contacted by phone, supplemented by an examination by a local physician. The same data and rating scales (including the SF-12) collected preoperatively were collected postoperatively in all patients. All data were independently tested for clinical significance by use of repeated-measures analysis of variance to test the hypothesis that there was a change between baseline and follow-up.

Surgical Technique

Surgery in this study was performed with the patient in the lateral decubitus position because of the senior author's preference. A standard posterior portal is used to access the joint and a diagnostic arthroscopy performed. Anterior-inferior and anterior-superior portals are then established. A complete capsular release outside the labrum is performed, and all degenerative fraying of the labrum, rotator cuff, and biceps is debrided. The arthroscope is then placed in the anterior-superior por-

TABLE 1. *Preoperative and Postoperative Rating Scores for All Patients*

Score (Maximum)	Preoperatively	Postoperatively	Significance
VAS pain (10)	8	2	$P < .001$
ASES (100)	22	78	$P < .001$
UCLA (35)	15	29	$P < .001$
Rowe (100)	55	81	$P < .001$
Constant-Murley (100)	26	79	$P < .001$
SF-12			
Physical functioning (100)	47	71	$P = .009$
Role-physical (100)	41	74	$P = .006$
Bodily pain (100)	27	68	$P < .001$
General health (100)	72	75	$P = .60$
Vitality (100)	46	66	$P = .002$
Social functioning (100)	54	84	$P < .001$
Role-emotional (100)	76	89	$P = .21$
Mental health (100)	64	77	$P = .003$
Range of motion (°)			
Flexion	80	150	
Abduction	60	120	
External rotation with arm at side	10	30	
External rotation–abduction	30	70	
Internal rotation	10	50	

tal and the shaver in the posterior portal to coplane the glenoid to a smooth surface. If the preoperative evaluation has shown the glenoid to be retroverted, this is corrected to normal glenoid version at this time, with the amount of resection determined by preoperative CT scan. The anterior-inferior labrum is preserved, because the smoothing of the glenoid allows the surgeon to elevate the labrum without removing it. The inferior 10% to 20% of the glenoid is beveled to prevent impingement on the inferior humerus.

The interposition graft is then prepared for insertion. In this study we chose the Restore patch (DePuy Orthopaedics) because of its biologic properties, presence of pluripotent cells, and compatibility with human tissue. The relative thinness of this graft requires the edge be rolled onto itself and sutured around its periphery to be able to hold the stay sutures (Fig 1). F1

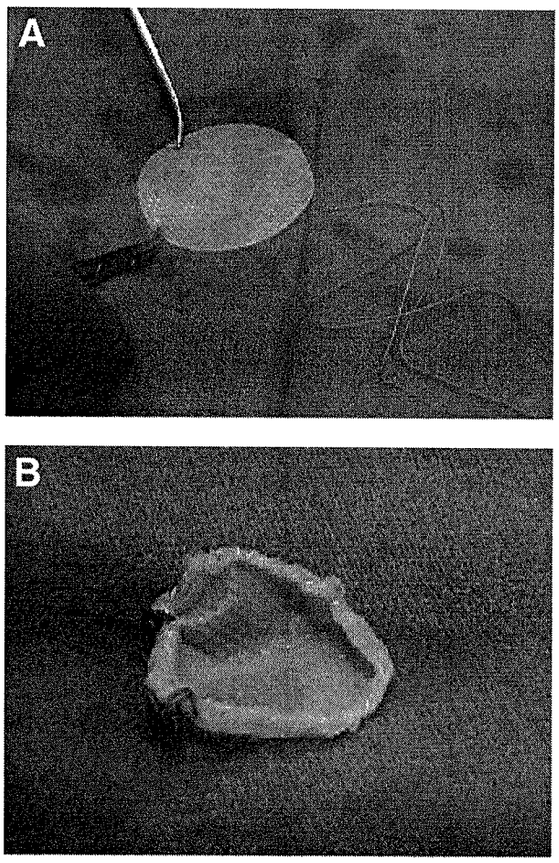

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FIGURE 1. (A) The hydrated Restore patch is placed for preparation. (B) The finished preparation of the graft with sutures in the 8- and 11-o'clock positions and the sutured rolled edge is ready for insertion.

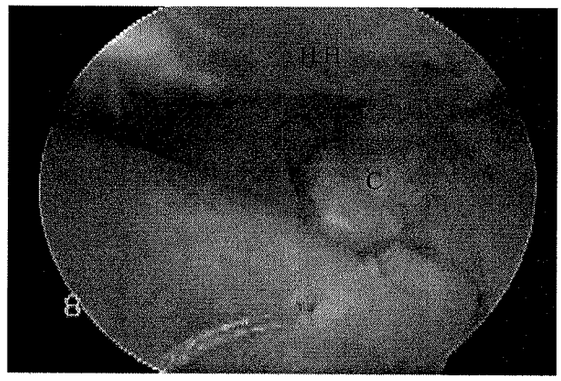

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FIGURE 2. The graft is inserted through the anterior cannula and secured anteriorly and posteriorly to lie flat on the glenoid. (HH, humeral head; C, anterior capsule.)

Ethibond No. 2 sutures (Ethicon, Somerville, NJ) are placed on the posterior aspect of the graft in positions that would correspond to the 8- and 11-o'clock positions on the glenoid. A cannula measuring 8 mm or larger is then placed in the anterior-inferior portal. An absorbable suture anchor is placed into the glenoid neck in the 1-o'clock position, and a second anterior suture or anchor is placed in the anterior-inferior labrum or capsule at the 4-o'clock position. These sutures are kept separate within the anterior cannula, being held in the anterior-inferior part and anterior-superior part of the cannula. The cap on the cannula is then removed to facilitate graft passage. The graft is then brought to the cannula and the anterior sutures placed through the graft, by use of free needles in the position that corresponds to their position on the glenoid. The posterior sutures in the graft are then placed into the joint one at a time and retrieved under the posterior labrum and out the posterior cannula by use of a 30° Ideal Suture Grasper (Mitek, Westwood, MA) at the 7- and 11-o'clock positions. These sutures are used to pull the graft through the cannula and into the joint. It is important to maintain gentle tension on the anterior sutures to prevent tangling. The posterior sutures are held tightly and the anterior-superior stitch tied and cut, allowing assessment of the graft position. The anterior-inferior suture is then tied and cut. The 2 posterior sutures are then tied together, completing the repair. The graft is assessed from all portals and additional sutures added as needed (Fig 2). F2

The patient is placed in an abduction pillow in 30° of abduction and neutral rotation for 4 weeks. Passive range-of-motion and active-assisted range-of-motion exercises are started at 4 weeks. Distraction and stretching

begin at 8 weeks postoperatively. Twelve weeks postoperatively, full physical therapy is initiated, and it is usually completed by 20 weeks after surgery.

RESULTS

All patients improved after the index operation. However, most patients did not see significant improvement until 3 to 4 months postoperatively, and they have continued to improve over the lifetime of the study. Five patients were initially successful but then deteriorated and had an additional surgery of humeral head surface replacement 1 to 5 years after the index operation, leaving an overall success rate of 75% at 3 to 6 years. Inspection of the glenoid in each of these cases showed the glenoid to be smooth and covered by what visually appeared to be articular cartilage. A sample was removed in each case and evaluated for thickness and viability. Each specimen recovered showed viable chondrocytes in a hyaline-like matrix of 1 to 6 mm in thickness (Fig 3). Four of these five patients thought the first operation was helpful and would undergo it again.

The mean range of motion improved in all planes tested: frontal flexion to 150° (range, 100° to 180°), abduction to 120° (range, 90° to 170°), external rotation with the arm at the side to 30° (range, 10° to 60°), external rotation at 90° of abduction to 70° (range, 45° to 90°), and internal rotation at 90° abduction to 50° (range, 30° to 80°) (Table 1).

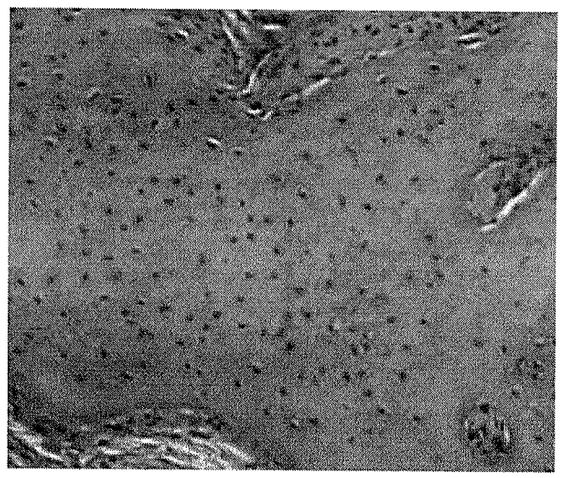

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FIGURE 3. A photomicrograph of a biopsy specimen of the tissue covering the glenoid, stained with H&E and taken at the time of humeral head resurfacing, showed viable chondrocytes embedded in a hyaline-like matrix.

The mean ratings of the entire group at final follow-up 3 to 6 years after surgery (including the failures at last visit before revision) were as follows: ASES, 78 (preoperatively, 22; $P < .001$); UCLA, 29 (preoperatively, 15; $P < .001$); Rowe, 81 (preoperatively, 55; $P < .001$); and Constant-Murley, 79 (preoperatively, 26; $P < .001$). The postoperative SF-12 scores were 71 for physical functioning (preoperatively, 47; $P = .009$), 74 for role-physical (preoperatively, 41; $P = .006$), 68 for bodily pain (preoperatively, 27; $P < .001$), 75 for general health (preoperatively, 72; $P = .6$), 66 for vitality (preoperatively, 46; $P = .002$), 84 for social functioning (preoperatively, 54; $P < .001$), 89 for role-emotional (preoperatively, 76; $P = .21$), and 77 for mental health (preoperatively, 64; $P = .003$). The mean VAS pain score was 2 (preoperatively, 8; $P < .001$) (Table 1). Thus all parameters, except general health and role-emotional, showed statistically significant improvement. Radiographs obtained at 6 months, 1 year, 3 years, and the most recent evaluation showed a space between the humeral head and the glenoid in all cases (Fig 4). MRI was performed in 19 of 20 shoulders 1 to 3 years postoperatively, and a CT scan of the remaining patient's shoulder was obtained 2 years postoperatively; the findings showed a persistent covering on the glenoid in all cases, with the thickness ranging from 1 to 6 mm as measured by an independent radiologist (Fig 5).

DISCUSSION

Arthroscopic management for early stages of osteoarthritis in young individuals has been shown to provide short-term pain relief even in the presence of grade IV osteochondral lesions.[14] Arthroscopic procedures for arthritis include debridement and irrigation, loose body removal, chondroplasty or abrasion of the glenoid and humeral head, synovectomy, and capsular release.[15] Weinstein et al.[16] showed satisfactory results in 92% of patients after arthroscopic debridement. These patients had a congruent joint and maintenance of the joint space, and they did not typically show the familiar osteoarthritic radiographic changes. The results did deteriorate with time in 24% of patients. Weinstein et al. did not advocate arthroscopy for the management of shoulders with advanced osteoarthritic changes. Our study differs from theirs in that we chose patients with grade IV degenerative changes, specifically excluded from their study. We have also chosen to observe this group for a longer period of time to avoid the short-term "placebo effect" of arthroscopic debridement.

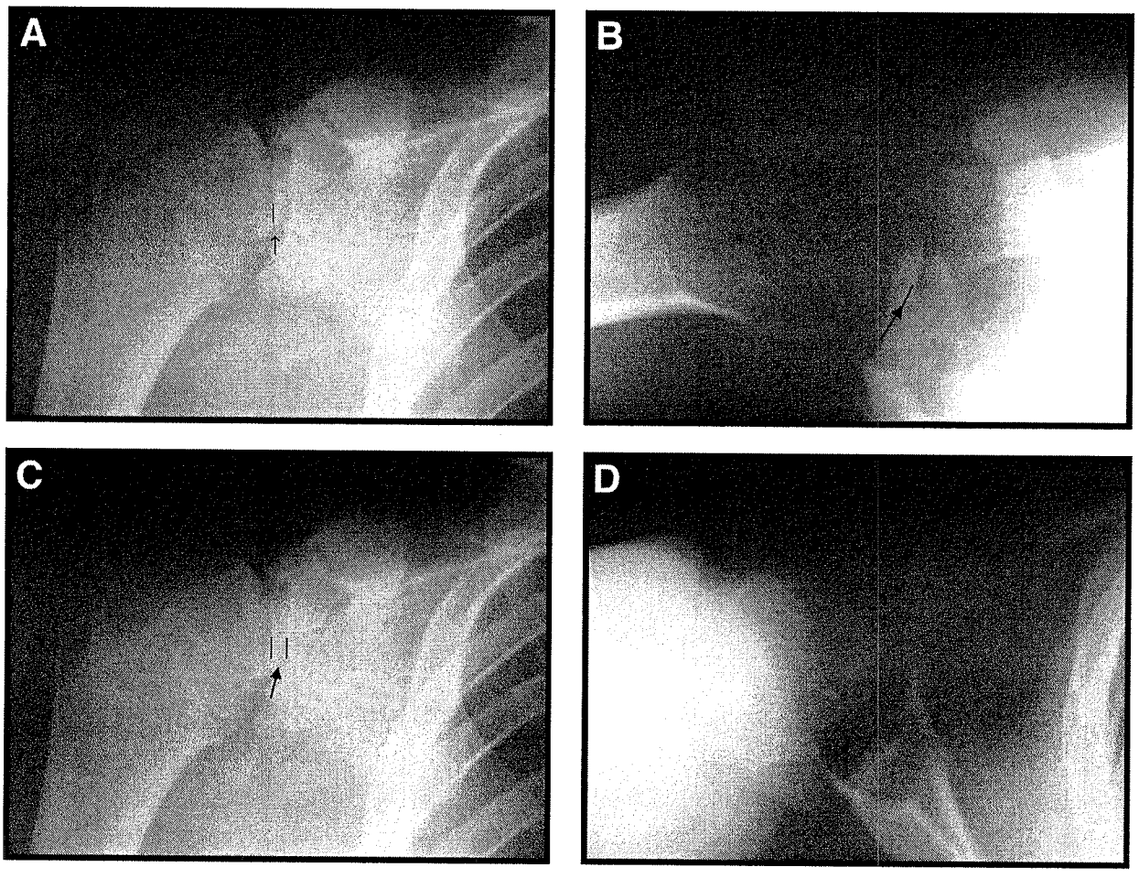

FIGURE 4. Preoperative (A, B) and postoperative (C, D) radiographs of a 16-year-old male patient in the study with severe degenerative changes due to chondrolysis, showing an increase in the distance between the humeral head and glenoid after resurfacing (arrows).

We initially published the technique of arthroscopic interposition grafting in 2004 with preliminary results but cautioned that realistic follow-up would be necessary to determine its effectiveness.[17] A similar technique was reported 2 years later as a technical note by Bhatia et al.[18] Our initial report detailed the preliminary results in the first 10 patients in whom we performed the index surgery, whereas that of Bhatia et al. focused on the technique only, with no reported results. The present study differs from our first study in both length of follow-up and the extensive postoperative evaluations of the patients. This is the first study to report midterm results of a completely arthroscopic procedure for resurfacing the glenohumeral joint as an alternative to shoulder arthroplasty. Although only the glenoid is resurfaced, this would be analogous to humeral head hemiarthroplasty in these degenerative shoulders. The midterm results, though not equal, do compare favorably with most results of isolated humeral head resurfacing or replacement in the young, active patient without the need for open surgery or detachment of the subscapularis.[1-5] The comparison is more favorable when patient satisfaction is included, because a higher percentage of these patients were very satisfied with their results as compared with the young, active patients in the group evaluated by Sperling et al.[1] Our patients' ability to return to recreational sporting activities also compared favorably with the results of the study by McCarty et al.,[19] in which an average of 72% of shoulder humeral hemiarthroplasty and total shoulder arthroplasty patients were able to return to their chosen sports. Our patients resumed a number of activities, including collegiate football (1), softball (1), and competitive water skiing (1), in addition to golf (10), tennis (3), and swimming (5). One difference between the study of McCarty

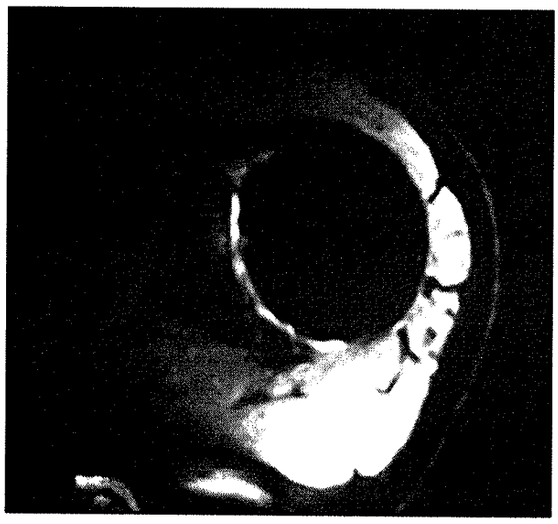

FIGURE 5. MRI scan of glenohumeral joint of a patient obtained at 3 years postoperatively showing 3 mm of covering on glenoid.

et al. and ours is our inclusion of chondrolysis patients along with those who had a post-traumatic and degenerative etiology. Although there was no statistically significant difference between groups because of the small numbers, the chondrolysis patients tended to improve more than the rest of the population and tended to attempt to return to a much higher level of sporting activity after glenoid resurfacing.

This procedure represents an attempt to biologically resurface the shoulder without the use of metal implants. The choice of the Restore patch centered on its pluripotent cell construct that would hopefully transform over time into the normal native tissue found in the area in which it is placed. In each of the patients in whom failure occurred, we performed a biopsy of the tissue covering the glenoid. The pathology department at our hospital performed H&E staining on the biopsy specimens, which showed the presence of viable chondrocytes and hyaline-like articular cartilage matrix of 3 to 6 mm in thickness. This presence of hyaline-like articular cartilage is encouraging, especially when correlated with the postoperative MRI scan showing a covering on the glenoid of 1 to 6 mm in thickness in all patients. Continued research into this area of arthroscopic placement of growth factor–impregnated patches may yield improved results and long-term satisfaction without shoulder replacement.

Several points became clear during the time period of the study. The Restore patch, though valued for its biologic properties, may be too thin to obtain a success rate of over 90% in this application. A more rigid structure that still contained pluripotent cells and growth factors might be more useful. The use of this patch has been associated with allergic-type reactions and a high complication rate when used to supplement rotator cuff repair as reported by both Iannotti et al.[20] and Walton et al.[21] Since the completion of this study, we have also noted a similar reaction in a patient in whom we used the Restore patch to supplement a rotator cuff repair. Although none of the patients in this study had this reaction, it is certainly possible that with its continued use, this would eventually occur, producing a similar problem. We now use a different biologic patch for these surgeries in an attempt to avoid this type of reaction.

Patient selection may also be a factor in the results. The exclusion of patients with deformity of the glenoid that would require bone grafting may have biased the results. However, in our practice these patients would not have been candidates for isolated humeral hemiarthroplasty but would have received total shoulder arthroplasty to allow us to reconstruct the glenoid with bone graft and then resurface the restored construct.

One issue that became apparent retrospectively is the predictive value of the shape of the humeral head on the axillary radiographs. We found that squaring of the head on the axillary view may be a relative contraindication for isolated arthroscopic glenoid resurfacing arthroplasty; in retrospect, 3 of our 5 cases of failure probably had too much of a misshapen humeral head for an isolated glenoid resurfacing graft to work long term. Each of these patients achieved short-term success but also represented the lower end of the improvement in both internal and external rotation. In our current treatment algorithm, these patients would receive an arthroscopically assisted total shoulder replacement, with arthroscopic biologic glenoid resurfacing combined with humeral head surface replacement via a subscapularis-sparing approach.

This also represents the first midterm report of a completely biologic rather than metal solution for the arthritic shoulder patient. The pioneering work of Burkhead and colleagues[6,7] should not be underestimated in stimulating this study. Their work set the stage to avoid the replacement of the glenoid and the problems of loosening associated with that portion of the procedure. This procedure simply represents a natural progression of their biologic glenoid resurfacing in combination with humeral head replacement. We have simply eliminated the added replacement of the humeral head. Krishnan et al.[7] have reported on the fate

of allografts in the shoulder used to resurface the glenoid. In their initial study using fascia lata to resurface the glenoid, Burkhead and Hulton[6] were able to biopsy one of the shoulders. Histology showed fibrous tissue, not fibrocartilage as they had hoped, but they felt encouraged by the continued presence of a fibrous covering of the glenoid. Our biopsy specimens seemed to show cartilage regrowth, an encouraging sign in these patients. Their more recent report on a variety of allografts, including Achilles tendon, showed satisfactory results in 91% of cases at 2 to 15 years' follow-up.[7] Our success rate, however, was only 75%, much lower than that reported by Burkhead and Hulton and Krishnan et al.

One difference in our study is the inclusion of post-chondrolysis patients along with the post-traumatic and degenerative patients. There was no statistically significant difference in results by etiology, although as a group, the chondrolysis patients tended to be on the higher end of the improvements noted for each parameter.

Weaknesses of this study include the lack of a randomized control group to compare with our operative group and the multifactorial etiology of the degenerative arthritis of the patients.

Despite these weakness, and although severe glenohumeral arthritis represents a difficult and perhaps unsolved problem, arthroscopic glenoid resurfacing by use of a biologic patch seems effective in the management of grade IV glenohumeral arthritis in the young, active patient at midterm follow-up. We hope that these results will serve as a start of further research into biologic alternatives to total shoulder arthroplasty of the degenerative shoulder.

CONCLUSIONS

Glenoid resurfacing with the Restore patch provided statistically significant improvements for young patients with severe glenohumeral arthritis as measured by the VAS, ASES, UCLA, Rowe, Constant-Murley, and SF-12 scores at 3 to 6 years of follow-up.

Acknowledgment: The authors thank Janet Rice, Ph.D., for the analysis of data and statistical relevance.

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