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ORIGINAL ARTICLE

Midterm results of osteochondral allograft transplantation to the humeral head

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Background: This study evaluated clinical outcomes of osteochondral allograft (OCA) transplantation for humeral head osteochondral defects. We hypothesized that patients with isolated humeral head disease would achieve favorable results and that patients with bipolar disease would experience inferior outcomes.

Methods: We identified patients who underwent humeral head OCA transplantation. Subjective questionnaire data were obtained preoperatively and at a minimum of 2 years postoperatively. Radiographs were evaluated for graft incorporation. Failure was defined by conversion to shoulder arthroplasty, American Shoulder and Elbow Surgeons score <50, or dissatisfaction with the surgical result.

Results: Twenty patients (65% male) met inclusion criteria. Patients were an average age of 24.8 ± 8.1 years. Eleven patients underwent concomitant glenoid surgery (microfracture or meniscal allograft resurfacing). Follow-up was available for 18 patients (90%) at mean of 67 months. All grafts incorporated except 2. Four patients underwent shoulder arthroplasty at mean of 25 months postoperatively (all after pain pump chondrolysis). Eleven of the 20 patients were satisfied (all dissatisfied patients underwent glenoid surgery). Significant improvements ($P < .001$) were seen for the visual analog scale (from 6.1 to 1.5), Simple Shoulder Test (from 32 to 73), American Shoulder and Elbow Surgeons score (from 39 to 76), and the physical component of the 12-Item Short Form Survey (from 38 to 48). Pain pump patients who did not progress to arthroplasty experienced inferior satisfaction (40% vs. 87.5%, $P = .04$) and a trend toward inferior outcomes compared with the rest of the cohort.

Conclusion: OCA transplantation is a viable option for young patients with isolated humeral chondral injury. Patients with bipolar disease or a history of intra-articular pain pump have increased failure and decreased subjective outcomes.

Level of evidence: Level IV; Case Series; Treatment Study

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Keywords: osteochondral allograft; osteochondral defect; humeral head; shoulder; cartilage restoration; chondrolysis

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Osteochondral defects involving the glenohumeral joint are less common than those in the knee or ankle; however, they are witnessed in 5% to 17% of patients undergoing shoulder arthroscopy.^{3,5,7,15} Numerous etiologies account for these lesions, including anterior and posterior instability, osteonecrosis, osteochondritis dissecans, osteoarthritis, inflammatory

arthritis, idiopathic chondrolysis, and iatrogenic injury, which may include the effects of intra-articular pain pumps, radiofrequency devices, and prominent suture anchors. All patients should undergo initial nonsurgical management, depending on the etiology and presence of a continued aggravating factor, such as retained hardware. However, when nonsurgical measures fail, a broad array of surgical treatment options exists for chondral lesions of the glenohumeral joint.

Surgical treatment options are generally categorized as reparative, restorative, or reconstructive. Reconstructive options, such as arthroplasty and humeral head resurfacing techniques, provide excellent improvement in pain and function but are best reserved for older, low-demand patients because of poor outcomes in young patients and complexity of revision.^{16,19} Surgical treatment options for symptomatic chondral lesions in young patients are generally restricted to reparative (marrow stimulation techniques) or restorative techniques, such as autologous chondrocyte implantation, osteochondral autograft, and osteochondral allograft (OCA).

A few moderately sized case series have suggested that microfracture may render favorable outcomes for small discrete lesions in the glenohumeral joint.^{4,13,17,18} However, literature on restorative techniques used for larger defects is limited primarily to a few case reports and small case series of OCA transplantation.^{2,6,8-10,12} These reports are most commonly in setting of reverse Hill-Sachs lesions involving the anteromedial humeral head after a posterior dislocation, and only 1 series contained more than 6 patients.²

Fresh OCA transplantation is characterized by the replacement of a chondral or osteochondral lesion with a graft composed of mature hyaline cartilage and supportive subchondral bone. This study investigated the functional outcomes and survivability of fresh OCA transplantation performed in patients with osteochondral defects of the humeral head resulting from any cause. We hypothesized that patients with isolated humeral head disease would experience favorable outcomes and that outcomes would be less favorable in patients with more widespread bipolar disease.

Materials and methods

The study was performed by retrospectively evaluating prospectively collected data for all patients who underwent fresh humeral head OCA transplantation between July 2004 and November 2011 in the practices of 2 fellowship-trained senior orthopedic surgeons (B.J.C., A.A.R.). We included all patients who were aged 18 years or older at the time of follow-up and at least 2 years after OCA transplantation.

Surgical treatment and rehabilitation

Humeral head OCA transplantation was performed open in 19 patients and arthroscopically in 1 patient. The open procedure was performed with the patient in the beach chair position, and the glenohumeral joint was approached through the deltopectoral interval.

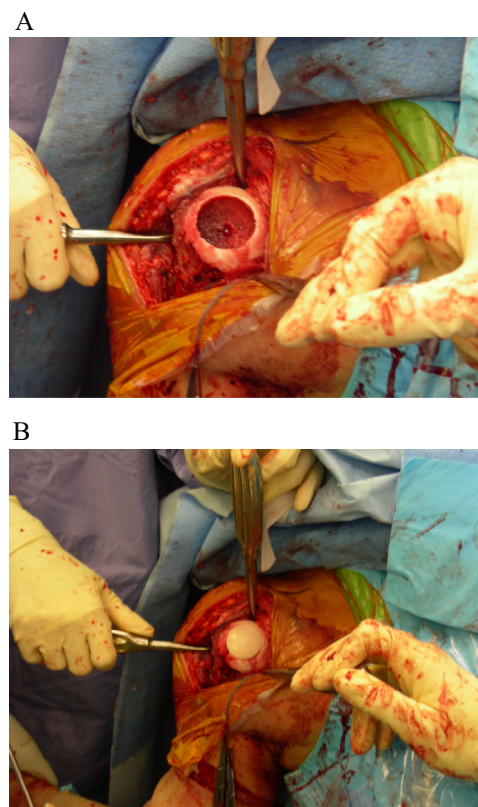


Figure 1 Intraoperative photographs demonstrate (A) the recipient socket after reaming of the osteochondral lesion and (B) a 30-mm osteochondral allograft after it has been press-fit into place.

The subscapularis was incised 1 cm to 1.5 cm medial to the biceps tendon.

When the humeral head lesion was relatively discrete, the choice was made to use an osteochondral plug. In such cases, the osteochondral defect was exposed by externally rotating the shoulder and débrided sharply using a curette. A guide pin was placed into the center of the lesion, and a cannulated reamer of the appropriate diameter (15-30 mm) was advanced to a depth of 6 to 9 mm to extricate the entire lesion (Fig. 1, A). A graft of the same diameter was prepared on the back table and press-fit into place (Fig. 1, B).

Contained defects measuring up to 30 mm in diameter were treated with allograft plugs; however, lesions that were larger or uncontained, or both, were generally treated with mushroom cap grafts to reconstruct the entire humeral head articular surface (Fig. 2). In such cases, upon entering the shoulder joint, the humeral head was osteotomized at the head-neck junction. A 15-mm reamer was used to establish a socket for the graft stem (Fig. 3, A). The graft was press-fit into place (Fig. 3, B). When the stability of the graft was a concern, supplemental fixation was achieved using bioabsorbable compression screws (Bio-Compression; Arthrex, Naples, FL, USA) or metallic headless compression screws (Acutrak 2 Standard; Acumed, Hillsboro, OR, USA; Fig. 4).

When the operation was performed arthroscopically, the patient was positioned in lateral decubitus, and the lesion was visualized through a posterior viewing portal (Fig. 5, A). A shaver was introduced through a standard anterior portal and used to débride the defect to a stable base. When sufficiently débrided, the graft recipient site



Figure 2 Mushroom cap osteochondral allograft used for wide-spread humeral head destruction.

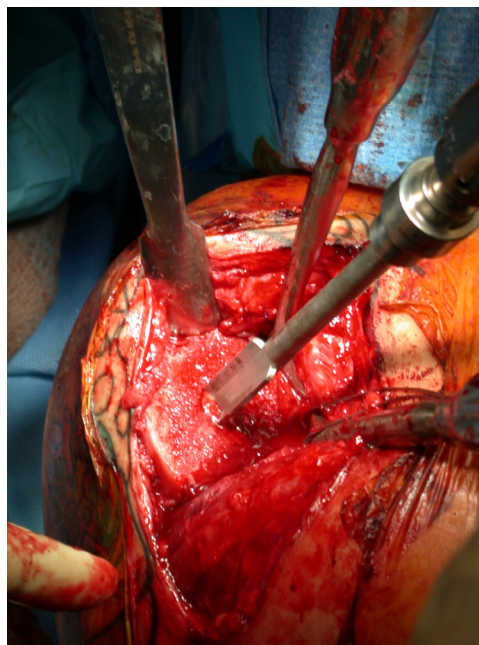
was prepared using an arthroscopic resurfacing system (Partial Eclipse; Arthrex, Naples, FL, USA).

A needle-targeting guide, similar to an anterior cruciate ligament guide, was used to place a guide pin through the lateral humerus into the center of the humeral head defect. A cannulated drill was advanced over the guide pin to create a hole of adequate diameter for the reamer shaft. The reamer shaft was inserted through this hole and connected intra-articularly to the reaming bit, which was inserted into the joint through an anterior rotator interval exposure measuring approximately 4 cm in length. The defect was reamed in a retrograde fashion to a depth of 6 mm (Fig. 5, B), and the graft was passed through the rotator interval and press-fit into place (Fig. 5, C).

In cases where lateral meniscal allograft interposition was used to resurface the glenoid, the meniscal allograft was removed from its bony insertions, and the anterior and posterior horns were sewn together with two 2-0 nonabsorbable sutures to create a concave structure. The remaining labrum was resected from the glenoid rim. The free meniscal graft was placed around the glenoid rim with the horns directed anteriorly such that the thickest portion of the labrum was directed posteriorly (covering the area of most significant wear). The graft was fixated circumferentially using 6 to 10 suture anchors sewn sequentially beginning posteriorly and superiorly. After reconstruction was complete, the subscapularis was carefully repaired, and a drain was placed.

Patients were maintained in a sling for 4 weeks after the operation. In patients undergoing open reconstruction, the first 6 weeks included passive and active-assisted range of motion with goals of 90° of forward flexion, 40° of external rotation at the side, and 75° of abduction without rotation. To protect the subscapularis, no active internal rotation was permitted, and external rotation was dictated by an intraoperative assessment of passive external rotation that avoided undue tension to the subscapularis. Beginning at 6 weeks, patients initiated gentle internal rotation strengthening, resisted external rotation, forward flexion, and abduction. At 12 weeks, patients initiated resisted internal rotation and extension exercises, began eccentric motions, and advanced strength as tolerated. Patients were not allowed to return to full activity sooner than 6 months from surgery.

A



B

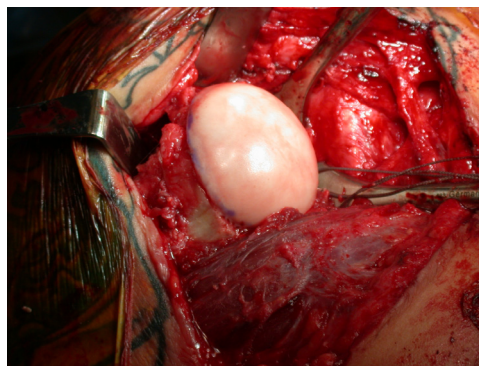


Figure 3 (A) Intraoperative view of the right proximal humerus after resection of the articular surface and reaming of 15-mm socket. (B) Mushroom graft after it has been impacted into the recipient socket in the proximal humerus.

Clinical assessment

Medical records were reviewed for details of presenting symptoms, age, etiology, sex, hand dominance, occupation, worker's compensation status, and previous surgical procedures. Operative notes of the transplantation procedure were reviewed to extract details of allograft details such as size, location, and fixation method. Patients were asked to complete the following validated questionnaires: visual analog scale (VAS) for pain, American Shoulder and Elbow Surgeons (ASES) shoulder assessment form, Simple Shoulder Test (SST), and the 12-Item Short Form Survey (SF-12). All patient-reported outcome questionnaires were collected preoperatively and during the most recent follow-up examination at a minimum of 2 years after surgery. When the functional scores were not available in review of medical records, phone interviews were conducted to gather all subjective information and to assess satisfaction with surgery about the operative shoulder. In addition, patients were queried about

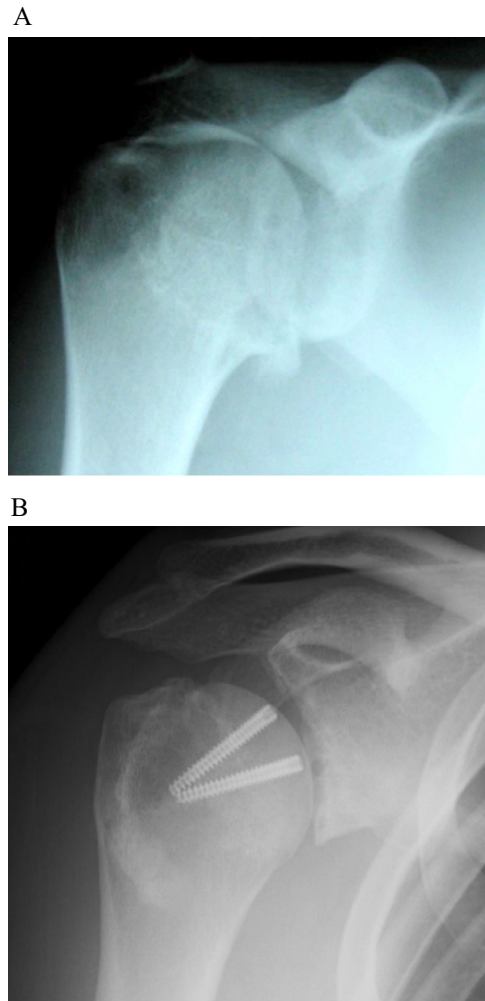


Figure 4 (A) Preoperative shoulder radiograph demonstrates advanced humeral head arthrosis with subchondral collapse and inferior osteophytes. (B) Postoperative anteroposterior radiograph reveals improved joint space and articular congruity in a patient who underwent mushroom humeral head allograft placement and fixation with 2 headless compression screws.

any further surgery on the operative shoulder after the allograft transplantation, including type of further surgery and the number of operations. Patient radiographic follow-up was obtained to evaluate graft incorporation and collapse.

Statistical analysis

Means and frequencies were calculated to summarize patient characteristics (age, sex, number of previous operations on the involved shoulder, diagnosis), allograft details (graft size and type), and follow-up data (number and type of further operations and patient satisfaction). Failure was defined as ASES score <50, dissatisfaction with the surgical result, or conversion to shoulder arthroplasty. Kaplan-Meier analysis of repair survival was performed, with conversion to arthroplasty used as the end point of interest. Among patients whose grafts remained in situ at the time of follow-up, paired *t* tests were used to compare preoperative and postoperative functional scores (VAS for pain, ASES, SST, and SF-12). The unpaired

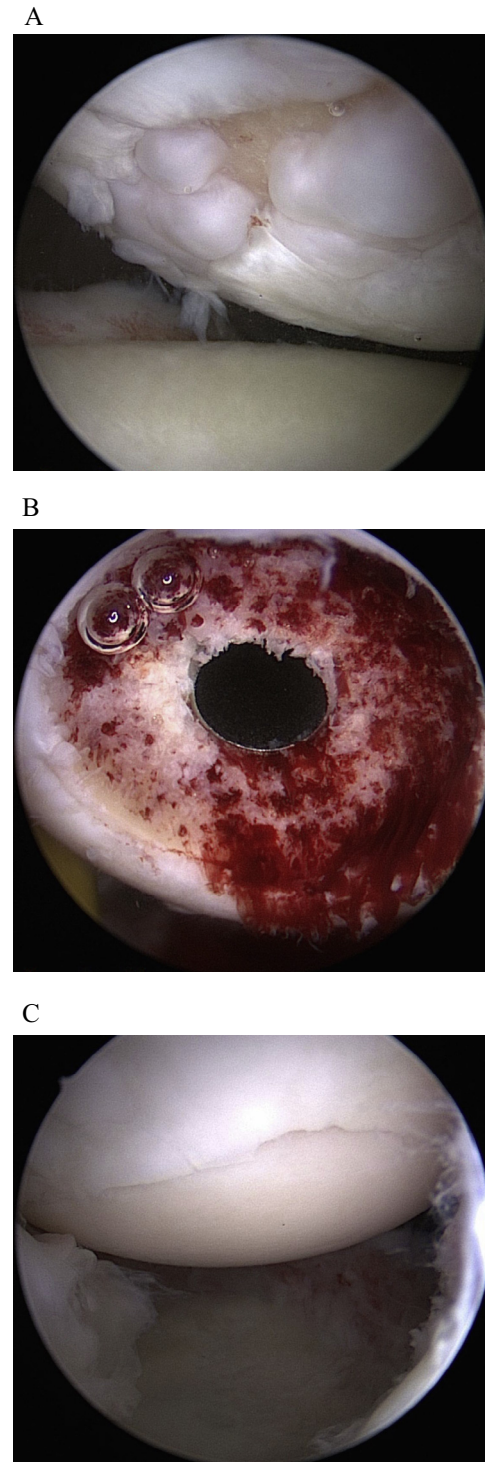


Figure 5 (A). Arthroscopic view of the right shoulder demonstrates full-thickness humeral head chondral defect, evaluated from the posterior viewing portal. (B) Arthroscopic view shows the lesion after retrograde reaming to a depth of 6 mm to accommodate the osteochondral graft. (C) Arthroscopic view shows the graft after it has been press-fit into place such that the articular surface is flush circumferentially.

t test was used to compare the pain pump cohort with patients with other etiologies. The χ^2 test was used to compare the rate of satisfaction between the pain pump cohort and that in patients with other etiologies. Results were considered statistically significant at $P < .05$. SPSS 23 software (IBM Corp, Armonk, NY, USA) was used for all statistical analysis.

Results

Between July 2004 and November 2011, 20 patients (13 men, 7 women) underwent OCA reconstruction of the humeral head (Table I). Patients were an average age of 24.8 ± 8.1 years (range, 15-42 years) at the time of surgery. The dominant shoulder was involved in 14 patients. Occupation was student in 13 patients, laborer in 2, and white-collar worker in 5. One patient was receiving workers' compensation, and 3 patients were involved in legal claims at the time of surgery. There were no smokers and no patients with diabetes.

Etiology included intra-articular pain pump in 10 patients, recurrent anterior instability in 4, reverse Hill-Sachs in 3, and prominent suture anchors, prior thermal capsulorrhaphy, and non-identifiable causes each in 1 patient. All patients had undergone prior surgical treatment to the operative shoulder, with the primary procedure being Bankart repair in 8 patients, superior labrum anterior and posterior repair in 5, capsulorrhaphy in 3, and superior labrum anterior and posterior débridement, microfracture, biceps tenodesis, and capsular release each in 1 patient. The average patient underwent 1.9 surgical procedures (range, 1-5 procedures) before OCA reconstruction, with many patients undergoing arthroscopic capsular release, microfracture, and débridement as temporizing efforts.

The reconstruction in 11 patients was done with allograft plugs (15-30 mm diameter), and 9 received mushroom allografts used to resurface the entire humeral head chondral surface. Six grafts were press-fit, and 14 required supplemental fixation with headless screws or bioabsorbable pins. Ten allografts were coupled with lateral meniscal allograft to simultaneously resurface the glenoid, and 1 additional patient underwent glenoid microfracture (8 mushroom,

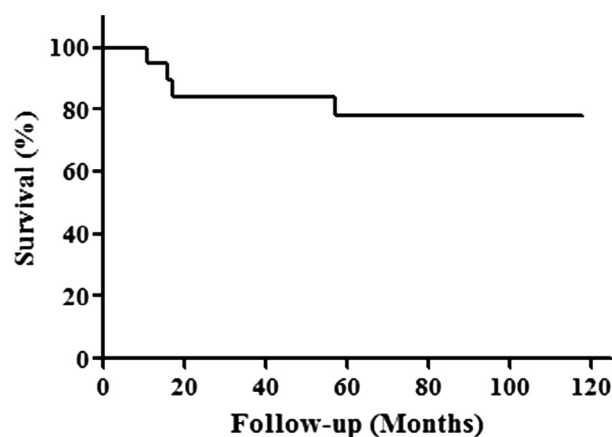


Figure 6 Kaplan-Meier survival curve demonstrates projected interval to conversion to arthroplasty after humeral head osteochondral allograft.

2 cylindrical). Of the 10 patients with pain pump etiology, 7 (70%) underwent concomitant glenoid surgery (6 lateral meniscal allograft, 1 microfracture) compared with 4 (40%) patients with other etiologies ($P = .18$).

Follow-up was available for 18 of 20 patients at an average of 66.5 months. There were 7 failures (39%): 4 patients (22%) underwent total shoulder arthroplasty at an average of 25 months (Fig. 6), and 3 additional patients (17%) reported that they were dissatisfied with the surgical result and would not undergo the procedure again. Two patients required postoperative capsular release, which was reportedly beneficial in both patients. All of the patients requiring reoperation had chondrolysis related to continuous infusion of local anesthetic via pain pump as the etiology of their chondral disease. Of the 7 clinical failures, 2 had mushroom grafts with evidence of graft collapse. Among the 14 patients whose allografts were still in place at the final follow-up, the subjective outcomes of pain and function improved significantly as measured by VAS, ASES, SST, and SF-12 physical (SF-12P) scores (Fig. 7). Among the 18 patients available for follow-up, 11 were satisfied with the procedure and would undergo the procedure again. Among the 7 patients who were dissatisfied, 6 had an etiology of pain pump chondrolysis, and all 7 underwent concomitant glenoid surgery (6 lateral meniscal allograft, 1 glenoid microfracture). Failures are reported as a product of graft type, glenoid procedure, and etiology in Table II. When the pain pump patients who did not progress to arthroplasty were analyzed, there were inferior postoperative subjective scores and patient satisfaction compared with patients with other etiologies (VAS, 2.2 vs. 1.6 [$P = .31$]; SST, 72 vs. 80 [$P = .26$]; ASES, 72 vs. 79 [$P = .17$]; SF-12P, 47 vs. 50 [$P = .22$]; patient satisfaction, 40% vs. 87.5% [$P = .04$]). Similarly, patients who underwent concomitant glenoid resurfacing with lateral meniscal allograft had inferior subjective scores, with a statistically significant reduction in the ASES score (66 vs. 83, $P = .049$).

Table I Patient characteristics

Clinical information	No. (%) or mean (range)
Patients and shoulders	20
Sex	
Male	13 (65)
Female	7 (35)
Age at surgery, y	24.8 (17-49)
Dominant shoulder	14 (70)
Shoulders with previous surgery	20 (100)
Previous operations, No.	1.9 (1-5)
Type of graft	
Plug	11 (55)
Mushroom	9 (45)
Allograft plug diameter, mm	24.6 (15-30)

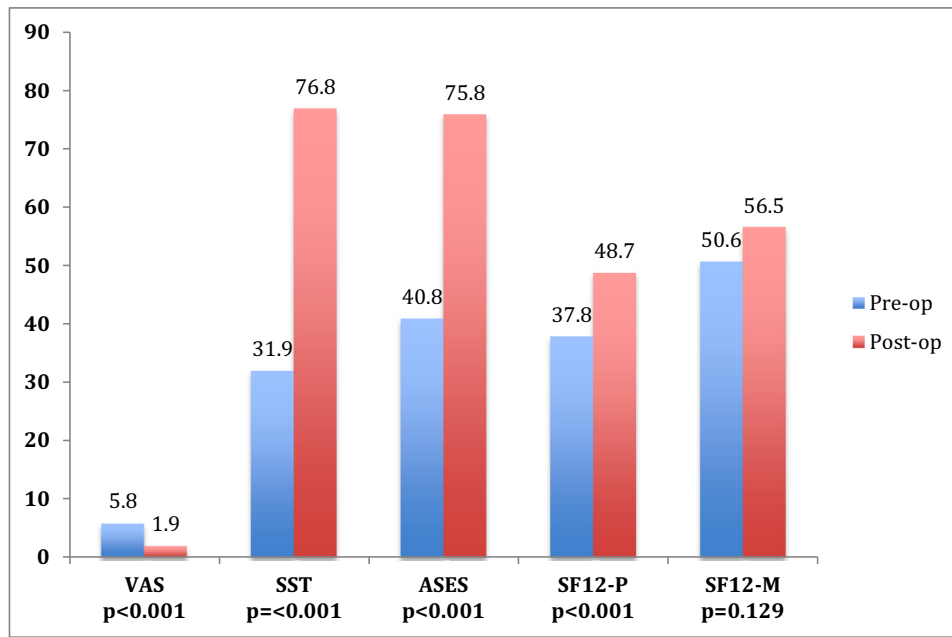


Figure 7 Preoperative and final follow-up subjective scores among patients who did not undergo total shoulder arthroplasty. ASES, American Shoulder and Elbow Surgeons; SF12M, 12-Item Short Form Survey mental component; SF12P, 12-Item Short Form Survey physical component; SST, Simple Shoulder Test; VAS, visual analog scale.

Radiographic analysis demonstrated that all grafts incorporated at an average of 14.8 months except in 2 patients. The operation in 1 of these patients with failure of incorporation was performed arthroscopically with a relatively shallow

socket depth (6 mm) and no supplemental fixation. The other patient with failure of incorporation was fixated with 2 supplemental screws; however, this case was complicated by *Propionibacterium acnes* infection and was ultimately revised

Table II Graft failures as a product of graft type, glenoid procedure, and etiology

Age (y)	Sex	Graft type	Glenoid procedure	Etiology	Failure
15	M	30-mm plug	LMA	Pain pump chondrolysis	Yes, dissatisfied
35	M	30-mm plug		Recurrent instability	No
16	F	27.5-mm plug	MFX	Pain pump chondrolysis	Yes, TSA
21	M	Mushroom	LMA	Pain pump chondrolysis	Yes, TSA
39	M	25-mm plug		Reverse Hill-Sachs	No
26	F	Mushroom	LMA	Pain pump chondrolysis	Yes, TSA
17	M	Mushroom		Pain pump chondrolysis	No
32	M	18-mm plug		Recurrent instability	No
20	M	Mushroom	LMA	Recurrent instability	LFU
19	F	30-mm plug	LMA + MFX	Pain pump chondrolysis	Yes, TSA
42	M	20-mm plug		Reverse Hill-Sachs	LFU
21	M	Mushroom	LMA	Recurrent instability	Yes, dissatisfied
25	M	30-mm plug		Pain pump chondrolysis	No
30	F	15-mm plug		Pain pump chondrolysis	No
20	F	Mushroom	LMA	Radiofrequency chondrolysis	No
19	M	Mushroom	LMA	Pain pump chondrolysis	Yes, dissatisfied
21	M	Mushroom	LMA	Pain pump chondrolysis	No
20	F	25-mm plug		Reverse Hill-Sachs	No
21	M	Mushroom	LMA	Prominent suture anchors	No
36	F	20-mm plug		Unknown	No

F, female; LFU, lost to follow-up; LMA, lateral meniscal allograft; M, male; MFX, microfracture; TSA, total shoulder arthroplasty.

to total shoulder arthroplasty. Mushroom grafts collapsed in 3 patients, with 2 of the 3 requiring revision to total shoulder arthroplasty.

Discussion

The principle finding of this study showed that the overall survival of OCA of the humeral head was 61% at mean follow-up of 66.5 months. The procedures in 7 patients (39%) were considered failures on the basis of conversion to total shoulder arthroplasty in 4 or subjective dissatisfaction in 3. Those who retained their allografts had significant improvement in pain scores, patient-reported outcomes, and subjective satisfaction.

Symptomatic chondral lesions in the glenohumeral joint are relatively common, witnessed in 5% to 17% of routine shoulder arthroscopies.^{3,5,7,15} Most patients with glenohumeral chondral defects should undergo an initial period of nonoperative treatment, including physical therapy, intra-articular steroid injections, and oral nonsteroidal anti-inflammatories. However, selecting the appropriate surgical intervention can be challenging when conservative measures fail. Many factors influence the choice of surgical technique, including the patient's age, level of demand, occupation, lesion size, and the presence of concomitant shoulder pathology (particularly glenoid chondral disease).

For older, lower-demand patients, palliative treatment options, such as arthroscopic débridement or capsular release, can afford predictable (70%-88%) short-term relief, particularly for small, well-contained lesions.^{1,21,22} Younger, active patients with focal contained defects can be effectively managed with reparative, marrow-stimulation techniques.^{4,13,17,18} Older patients (aged >65 years) with more widespread disease are often best managed with total shoulder arthroplasty or reverse total shoulder arthroplasty.

Young, active patients with widespread cartilage destruction, particularly those with compromised subchondral bone or bipolar disease, remain the most challenging patient population because arthroplasty has witnessed poor results in younger patients. Sperling et al¹⁹ demonstrated only 61% survival at 10 years in 33 patients (mean age, 46 years) undergoing shoulder arthroplasty. Schoch et al¹⁶ reported 20-year results for 56 hemiarthroplasties and 36 total shoulder arthroplasties in patients aged <50 years. Although the authors reported relatively higher survival, they noted a significant proportion of patients with unacceptable Neer ratings and recommended caution in considering shoulder arthroplasty in young patients.

Recently, biologic reconstruction has been increasingly advocated in this patient population with the goals of decreasing pain, restoring durable functionality, and delaying consideration of shoulder arthroplasty. The main techniques for biologic reconstruction of the humeral head are osteochondral grafting with allograft or autograft and autologous chondrocyte implantation. Biologic reconstruction of the glenoid generally involves interposition with anterior shoulder capsule,

autogenous fascia lata, lateral meniscal allograft, Achilles tendon allograft, and xenograft, among others. Available evidence regarding glenoid resurfacing has been discouraging^{14,20}; however, there is some limited evidence supporting the use of OCA for humeral head osteochondral defects.

There are 3 small case series in the literature on use of OCA for humeral head articular restoration.^{2,6,10} Gerber and Lambert⁶ reported little or no pain and minimal functional limitation in 3 of 4 patients who underwent OCA for massive reverse Hill-Sachs at 5.5 years of follow-up. Martinez et al¹⁰ reported long-term results of 6 men who underwent OCA for reverse Hill-Sachs lesions and noted that 3 of 6 had graft collapse (n = 2) or progression of osteoarthritis (n = 1) necessitating total shoulder arthroplasty within 10 years of reconstruction. Diklic et al² reported outcomes in 13 patients with locked, unreduced posterior dislocations treated with OCA for impaction fractures constituting 25% to 50% of the humeral head articular surface. At 54 months of follow-up, 9 patients had no pain or restriction of activities, and no patients had symptoms of instability.

The results from this study support the results from Gerber and Lambert⁶ and Diklic et al,² suggesting that OCA is an acceptable treatment option for isolated chondral defects of the glenohumeral joint. The 9 patients in the series who underwent isolated reconstruction of the humeral head were satisfied with the results of the operation and would undergo the procedure again. Among the patients who did not go on to total shoulder arthroplasty, there was a statistically significant reduction in pain and statistically significant increases in VAS, ASES, SST, and SF-12P subjective scores (Fig. 7).

Among the 20 patients who underwent OCA reconstruction, 10 had an etiology of chondrolysis secondary to continuous intra-articular infusion of local anesthetic via a pain pump. Intra-articular pain pumps have been strongly linked to widespread, bipolar cartilage destruction, with at least 213 cases of glenohumeral chondrolysis secondary to postoperative intra-articular infusion of local anesthetic reported in the literature.¹¹ Local anesthetics are known to be cytotoxic to chondrocytes because they disrupt cell membranes, slow mitochondrial respiration, and compromise mitochondrial DNA, leading to apoptosis.¹¹ For this reason, one would anticipate that chondrolysis in the setting of an intra-articular pain pump would result in widespread destruction of the humeral head and glenoid articular surfaces. We found that 7 of the 10 patients in our series with history of an implanted pain pump had bipolar disease necessitating a restorative or resurfacing procedure on the glenoid side (lateral meniscal interposition in 5 patients and glenoid microfracture in 2 patients). Patients with a history of intra-articular pain pump constituted 6 of the 7 patients who were dissatisfied with the osteochondral allograft reconstruction, and all 6 patients required a subsequent operation (including all 4 who required conversion to total shoulder arthroplasty).

Strauss et al²⁰ recently demonstrated a clinical failure rate of 45% at 3.4 years in 31 patients who underwent lateral meniscal allograft interposition. Likewise, Muh et al¹⁴ demonstrated poor functional improvement and conversion to total

shoulder arthroplasty in 7 of 16 patients (44%) who underwent glenoid resurfacing with allograft Achilles tendon or allograft human dermal matrix (GraftJacket; Wright Medical Technology, Arlington, TN, USA). In light of the poor results of biologic glenoid resurfacing and the significant prevalence of bipolar disease in the pain pump cohort, the inferior clinical outcomes witnessed in this patient population are relatively anticipated.

The study has several limitations. The patient cohort is small (20 shoulders). The number does not allow for correlating factors, such as previous operations, type of procedure performed (plugs or mushroom grafts, with or without lateral meniscal allograft), and size of graft, with outcomes. However, as far as we are aware, this is the largest series of patients in the literature who have undergone biologic reconstruction of the humeral head. In addition, similar to most other studies on OCA transplantation (knee, elbow, ankle), this is a retrospective case series without a control group. However, critical evaluations of small- to medium-sized retrospective case series are important before proceeding with large prospective trials.

We defined failure as the dissatisfaction with the surgical procedure or conversion to arthroplasty. We acknowledge that our patients may have resisted proceeding with revision arthroplasty because it is an unfavorable salvage option in young patients, thus increasing the rate of survival. Nevertheless, those patients' clinical outcomes are reflected by their lower functional scores.

Conclusion

Fresh OCA transplantation is a useful treatment option for appropriately selected young patients with significant chondral injury to the humeral head. In patients with isolated defects of the humeral head, it renders predictably favorable results with reasonable durability at a minimum 2-year follow-up. In patients with humeral and glenoid involvement or etiology secondary to an intra-articular pain pump, OCA transplantation has an increased risk of failure and less favorable subjective outcomes.

Disclaimer

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