Survivorship and Patient-Reported Outcomes After Comprehensive Arthroscopic Management of Glenohumeral Osteoarthritis

Minimum 10-Year Follow-up

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Background: Few long-term outcome studies exist evaluating glenohumeral osteoarthritis (GHOA) treatment with arthroscopic management.

Purpose: To determine outcomes, risk factors for failure, and survivorship for the comprehensive arthroscopic management (CAM) procedure for the treatment of GHOA at minimum 10-year follow-up.

Study Design: Case series; Level of evidence, 3.

Methods: The CAM procedure was performed on a consecutive series of patients with advanced GHOA who opted for joint preservation surgery and otherwise met criteria for total shoulder arthroplasty. At minimum 10-year follow-up, postoperative outcome measures included change in the American Shoulder and Elbow Surgeons, Single Assessment Numeric Evaluation, 12-Item Short Form Health Survey (SF-12) Physical Component Summary, and visual analog scale for pain, along with the QuickDASH (shortened version of Disabilities of the Arm, Shoulder and Hand) and satisfaction score. Kaplan-Meier survivorship analysis was performed, with failure defined as progression to arthroplasty.

Results: In total, 38 CAM procedures were performed with 10-year minimum follow-up (range, 10-14 years) with a mean patient age of 53 years (range, 27-68 years) at the time of surgery. Survivorship was 75.3% at 5 years and 63.2% at minimum 10 years. Those who progressed to arthroplasty did so at a mean 4.7 years (range, 0.8-9.6 years). For those who did not undergo arthroplasty, American Shoulder and Elbow Surgeons scores significantly improved postoperatively at 5 years (63.3 to 89.6; $P < .001$) and 10 years (63.3 to 80.6; $P = .007$). CAM failure was associated with severe preoperative humeral head incongruity in 93.8% of failures as compared with 50.0% of patients who did not go on to arthroplasty ($P = .008$). Median satisfaction was 7.5 out of 10.

Conclusion: Significant improvements in patient-reported outcomes were sustained at minimum 10-year follow-up in young patients with GHOA who underwent a CAM procedure. The survivorship rate at minimum 10-year follow-up was 63.2%. Humeral head flattening and severe joint incongruity were risk factors for CAM failure. The CAM procedure is an effective joint-preserving treatment for GHOA in appropriately selected patients, with sustained positive outcomes at 10 years.

Keywords: shoulder; arthroscopic management; glenohumeral osteoarthritis; 10-year outcomes

Glenohumeral osteoarthritis (GHOA) remains a common cause of shoulder pain, loss of shoulder range of motion, and upper extremity dysfunction in >20 million Americans.[2,10] Nonoperative management of GHOA is the first-line treatment of choice, and it consists of activity modification, physical therapy, nonsteroidal anti-inflammatory medications, and intra-articular injections.[1] When nonsurgical measures fail, surgical considerations include arthroscopic debridement, biological interposition arthroplasty, hemiarthroplasty, and total shoulder arthroplasty (TSA).[1,6]

Although TSA is considered the gold standard surgical treatment for advanced GHOA in most patients, young or particularly active patients often wish to avoid or delay TSA given concerns regarding implant longevity, potential for revision surgery, and activity limitations. Furthermore, less desirable outcomes have been reported after TSA in young patients, in part because of increased patient expectations and higher patient demands.[4,7] For this

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reason, arthroscopic treatment options have been used in an attempt to delay TSA in younger, more active patients and in those patients in whom TSA is otherwise not an acceptable treatment option.[3,5,12-14,17,21,22]

The comprehensive arthroscopic management (CAM) procedure was introduced by Millett et al[12,13,16,18] in an attempt to address the known pain generators of the osteoarthritic shoulder. The CAM procedure builds on previously described arthroscopic techniques for GHOA, including debridement, chondroplasty, synovectomy, loose body removal, capsular release, and subacromial decompression, but adds inferior humeral osteoplasty, a complete capsular release, axillary nerve neurolysis, long head of the biceps tenodesis, and microfracture.[14,18,21,22,25] CAM procedure outcomes for GHOA after a minimum of 2 and 5 years have shown promising results.[13,16] Patients who underwent the CAM procedure reported significant improvement in American Shoulder and Elbow Surgeons (ASES) score and pain levels. Survivorship analysis, as defined by progression to TSA, showed a 92% survivorship at 1 year, 85% at 2 years, and 76.9% at 5 years. However, long-term survivorship has yet to be reported.

The purpose of this study was to report long-term outcomes and survivorship for the CAM procedure when used in the treatment of GHOA, with a minimum 10-year follow-up. It was hypothesized that while some patients would progress to TSA, the majority would demonstrate sustained improvement in patient-reported outcomes and satisfaction without conversion to TSA at long-term follow-up.

METHODS

Patient Cohort

Institutional review board approval (No. 2019-50) was obtained before the initiation of this retrospective analysis of prospectively collected data. A total of 47 patients who underwent the CAM procedure (n = 49) for the treatment of GHOA by the senior author (P.J.M.) between January 2006 and October 2009 were evaluated. Eight patients refused to participate, 1 died, and 1 left the country and was unable to be contacted, leaving 37 patients for review. Patients were indicated for the CAM procedure if they had advanced GHOA (Kellgren-Lawrence grade $\geq$3) and a course of nonoperative management had failed, including a combination of activity modification, physical therapy, nonsteroidal anti-inflammatory drugs, and intra-articular corticosteroid injections. All met the clinical and radiographic criteria for total shoulder joint replacement, which included the aforementioned indications for the CAM procedure; however, they elected to undergo a joint-preserving technique to avoid or delay TSA. Exclusion criteria for the current study were (1) early-stage GHOA (Kellgren-Lawrence grade 1 or 2), (2) no trial of nonoperative measures, (3) irreparable rotator cuff tears, and (4) severe bipolar chondral lesions with diffuse flattening of the humeral head. During patient counseling, TSA was suggested over the CAM procedure if patients had a type B2 or C glenoid according to the Walch classification or <2 mm of glenohumeral joint space, as these criteria were shown to correlate with unfavorable outcomes in previous research.[16,17] However, patients with these criteria were allowed to make their own treatment decision and were not excluded from undergoing a CAM procedure or from this analysis.

Surgical Technique

The CAM procedure was performed using the technique described by Millett et al.[12,13,16-18] In brief, range of motion was first assessed, followed by diagnostic arthroscopy. Debridement of degenerative labral tears, unstable chondral injuries, and synovitis was performed. In cases of high-grade focal chondral defects, microfracture was utilized. Loose bodies were removed. If instability or pathology of the intra-articular biceps was noted, the tendon was released at its origin, and a subpectoral tenodesis was performed after the arthroscopic portion of the surgery. Inferior humeral osteophytes were resected if present via an accessory posteroinferior portal utilizing an arthroscopic bur and curved curette.[18] Dynamic fluoroscopy in internal and external rotation was used to ensure complete resection of the inferior humeral osteophytes.

Next, the inferior glenohumeral capsule was released. If the inferior humeral osteophyte appeared to affect the course of the axillary nerve on preoperative magnetic resonance imaging or intraoperatively or if patients' symptoms were consistent with nerve compression, axillary neurolysis was performed. An anterior and posterior capsular release was then carried out, and the rotator interval was released. A subcoracoplasty was performed if needed, as was acromioplasty.[9,19] Range of motion was then again assessed postoperatively.

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Postoperative Rehabilitation

The postoperative rehabilitation regimen comprised 3 phases aimed to improve and maintain motion, avoid contracture, and improve scapulothoracic and glenohumeral mechanics. In the first phase—which was begun immediately postoperatively and facilitated by the preoperatively administered interscalene block—passive and active assisted motion was emphasized. In the second phase, which began at 4 to 6 weeks postoperatively, strengthening was the focus. The final phase was initiated at approximately 12 weeks and focused on return to activities.

Outcome Scores

Patient data collected included age, sex, dominant shoulder, workers' compensation status, and previous surgery. Objective data included grade of GHOA according to the Kellgren-Lawrence scale and Outerbridge grade of the humerus and glenoid. Walsh classification was recorded, as was the size of the inferior humeral and glenoid osteophytes. Joint space was measured on anteroposterior radiographs at the superior, middle, and inferior third, and the smallest value was reported. Critical shoulder angle and humeral head–acromial distance were also measured. A new classification system for humeral head incongruity was also derived from clinical observation, with grade 0 being normal congruity; grade 1, inferior incongruity; grade 2, distinct central flattening; and grade 3, severe incongruity (Figure 1). Two blinded independent fellowship-trained orthopaedic sports medicine surgeons (J.W.A. and D.B.H.) graded radiographs according to this classification scheme, and inter- and intrarater reliability was assessed. Other radiographic assessments were previously assessed and showed substantial to almost perfect agreement.[17] Intraoperative findings, procedures performed, complications, and further surgical interventions after the CAM procedure were documented. These metrics were compared between those patients who did and did not progress to TSA.

Patient-reported outcome scores included preoperative ASES, Single Numeric Assessment Evaluation (SANE), QuickDASH (shortened version of Disabilities of the Arm, Shoulder and Hand), and SF-12 (Physical Component Summary). At a minimum follow-up of 5 and 10 years after the CAM procedure, the aforementioned scores were collected again. Additionally, patient satisfaction with surgery (1-10; 10, very satisfied) was evaluated at minimum follow-up of 5 and 10 years. Before 2010, SANE and QuickDASH scores were not routinely collected preoperatively; therefore, analysis of these patients was limited to postoperative scores in regard to SANE and QuickDASH. Complications and further surgical intervention after the index procedure were recorded. Failure was defined as progression to TSA.

At minimum follow-up of 5 and 10 years postoperatively, questionnaires comprising the aforementioned scores were sent to the patients. If patients did not return their questionnaires by mail, they were contacted via telephone or email and encouraged to return their questionnaires. No questions regarding the outcome scores were asked via telephone, to avoid response bias. Some patients in the current study cohort were included in previously published 2- and 5-year outcome studies.[13,16]

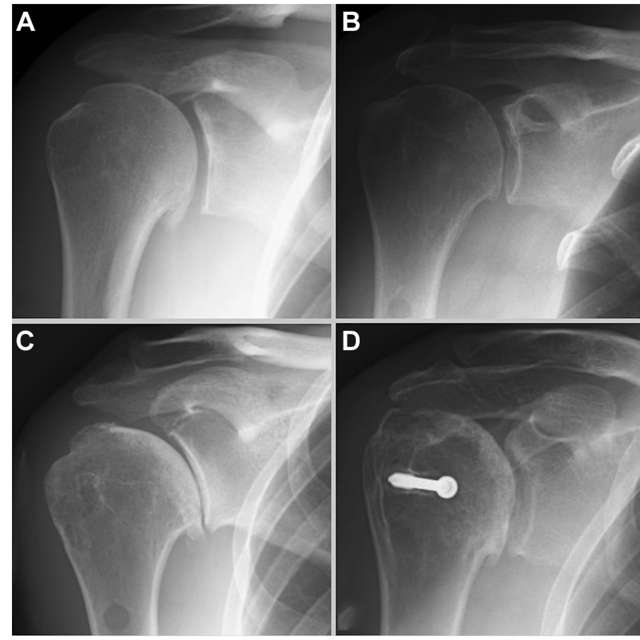

Figure 1. Humeral head incongruity classification system based on clinical observation: (A) grade 0, normal congruity; (B) grade 1, inferior congruity; (C) grade 2, distinct central flattening; (D) grade 3, severe incongruity.

Statistical Analysis

Statistical analysis was performed with SPSS Version 11.0 (IBM Corp), and the risk factor analysis was done using statistical package R Version 3.5.2 (R Development Core Team; with additional package *rms*).[20] Categorical data are presented as number and percentages and continuous data as mean and standard deviation. An independent or paired t test was used for univariate analysis for normally distributed variables. For nonparametric data, the Mann-Whitney or Kruskal-Wallis test was performed. To assess risk factors of failure, bivariate analysis was conducted using simple logistic regression for continuous covariates and Fisher exact test for discrete covariates. Survivorship analysis was performed using Kaplan-Meier survival curves for progression to TSA as an endpoint. Inter- and intrarater measurement repeatability for humeral head congruency grade was assessed using the weighted kappa statistic. Disagreements between rounds or raters were weighted per the squared distance from perfect agreement. The measurement agreement analysis was performed with the statistical package R Version 4.0.0 (R Development Core Team; with additional packages *irr* and *boot*). The level of significance was set at $P < .05$.

TABLE 1
Patient Characteristics and Imaging Findings[a]

	CAM Survivors[b]	CAM Failures[c]	*P* Value
Age, y, mean ± SD	54.4 ± 8.9	50.7 ± 10.2	.172
Sex, male:female, No.	17:6	11:4	.329
Dominant arm, %	50	56	.752
Previous surgery, %	69	50	.743
Grade, median (range)			
Kellgren-Lawrence	3 (2-4)	4 (3-4)	.279
Outerbridge: humerus	4 (3-4)	4 (3-4)	.289
Outerbridge: glenoid	4 (0-4)	4 (0-4)	.196
Walch classification B2 or C, %	14.3	40	.083
Spur size, mm, mean ± SD			
HH	8.1 ± 4.4	11.4 ± 6.7	.095[d]
Glenoid	4.3 ± 2.4	6.5 ± 4.1	.117
HH incongruity, grade, median (range)	2 (0-3)	3 (1-3)	.006[e]
<2-mm joint space, %	43	67	.192
Critical shoulder angle	31.4 ± 4.8	28.6 ± 5.6	.107
HH-acromial distance, mm	9.7 ± 1.8	12.6 ± 7.0	.131

[a]Two men without outcomes are removed from analysis. CAM, comprehensive arthroscopic management; HH, humeral head.
[b]Patients who underwent CAM for glenohumeral arthritis and did not progress to arthroplasty at 10-year minimum follow-up.
[c]Patients who underwent CAM for glenohumeral arthritis and progressed to arthroplasty.
[d]Increasing humeral heard spur size was a significant risk factor for failure with regression analysis (β = 0.144; 95% CI, 0.026-0.288; P = .030).
[e]$P < .05$.

RESULTS

A total of 38 CAM procedures (37 patients) were performed between January 2006 and October 2009 with minimum 10-year follow-up. The mean follow-up was 10 years (range, 10-14 years). Ten women and 27 men met inclusion criteria, with a mean age at surgery of 53 years and median age of 54 years (range, 28-68 years). Twenty-three shoulders (60.5%) did not progress to TSA after CAM surgery at minimum 10-year follow-up. Those that progressed to TSA did so at a mean of 4.7 years (range, 0.8-9.6 years). Of the 23 patients, 20 (87.0%) who did not undergo TSA were evaluated at a mean 11.2 years (range, 10-13.1 years). Kaplan-Meier survivorship was 75.3% at 5 years and 63.2% at 10 years (Figure 2), with 5 patients progressing to an arthroplasty between 5 and 10 years postoperatively. Table 1 presents further demographic and imaging data. There was no difference in the surgical procedures performed between those who did and did not progress to TSA (Table 2). Range of motion significantly improved after CAM surgery in both groups (Table 3).

For patients who did not progress on to TSA, ASES scores showed significant pre- to postoperative improvement at 5 years (63.7 to 84.2; $P < .001$) and 10 years (63.7 to 80.6; P = .007). There was no difference between 5- and 10-year ASES scores (84.2 vs 80.6, P = .096) or QuickDASH scores (16.8 vs 17.7; P = .760). SANE scores did significantly decrease between 5- and 10-year follow-up (82.3 vs 73.4; P = .033). Median satisfaction at 11.2 years after CAM surgery was 7.5 (range, 1-10) (Table 4).

Preoperative images showed a mean acromion–humeral head distance of 10.2 mm (range, 5.5-19.8 mm), osteophyte

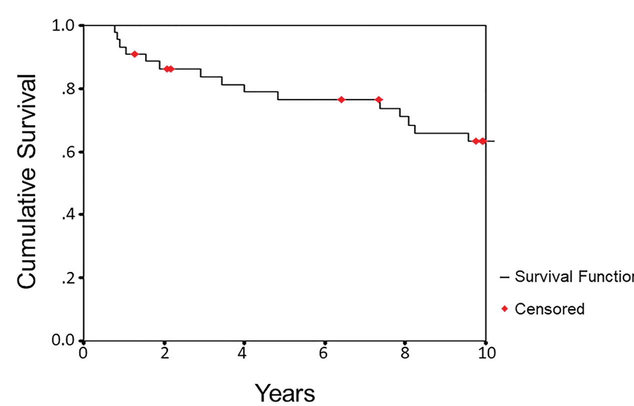

Figure 2. Kaplan-Meier CAM survivorship curve for glenohumeral arthritis: 75.3% at 5 years and 63.2% at 10 years. CAM, comprehensive arthroscopic management.

TABLE 2
Surgical Procedures in CAM Survivors vs Failures[a]

	CAM Survivors	CAM Failures	*P* Value
Long head biceps tenodesis	42	69	.121
Humeral head ostectomy	37	56	.341
Synovectomy	89	81	.658
Microfracture	31	6.2	.067

[a]Values are presented as percentages. CAM, comprehensive arthroscopic management.

TABLE 3
Range of Motion During Examination Under Anesthesia[a]

	CAM Survivors			CAM Failures		
	Preoperative	Postoperative	*P* Value	Preoperative	Postoperative	*P* Value
Forward flexion	124	166	.001	122	144	.001
External rotation	35	69	<.001	32	57	.011
External rotation at 90°	41	86	<.001	40	68	<.001
Internal rotation	33	56	.033	38	58	.001

[a]Values are presented as degrees. All *P* values <.05. CAM, comprehensive arthroscopic management.

TABLE 4
Outcome Parameters[a]

		Postoperative		*P* Value	
	Preoperative	5 y	10 y	Preoperative vs 10 y	5 vs 10 y
ASES	63.7 ± 14.2	84.2 ± 18	80.6 ± 19.4	.007[b]	.096
SANE		82.3 ± 21	73.4 ± 30.1		.033[b]
QuickDASH		16.8 ± 15.7	17.7 ± 18.2		.760
SF-12 PCS	48.8 ± 6.5	52.3 ± 8.0	48.3 ± 10.3	.866	.174
Satisfaction, 1-10		9.5	7.5		.028[b]
Pain, 0-3	3		1	.001[b]	

[a]Values are presented as mean ± SD or median score. ASES, American Shoulder and Elbow Surgeons; QuickDASH, shortened version of Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary.
[b]$P < .05$.

size of 9.5 mm (range, 1.4-28.8 mm), and joint space of 2.0 mm (range, 0-5.3 mm). CAM failure was significantly associated with more humeral head incongruity, with 93.3% (14/15) of CAM failures having central flattening and severe incongruity versus 50% of the nonfailures (P = .008). Intra- and interrater reliability between the 2 reviewers was excellent (weighted kappa, 0.956 and 0.933, respectively). Spur size on the humeral head was a statistically significant predictor of CAM failure (ß = 0.144; 95% CI, 0.026-0.288; P = .030). This can be interpreted such that a 1-mm change in humeral head spur size results in an estimated increase in the log odds of failure by 0.144. Glenoid spur size was not a statistically significant predictor of CAM failure (ß = 0.119; 95% CI, –0.061 to 0.294; P = .215) (Table 1).

One patient underwent a second surgical procedure for stiffness at 5.6 months. A second patient underwent a revision CAM procedure at 7.9 years and then underwent TSA 11 months later. No additional intra- or postoperative complications were observed in this cohort.

DISCUSSION

This study suggests that CAM of glenohumeral joint arthritis improves shoulder function, decreases pain, and has a 63.2% survival at minimum 10-year follow-up. Those who underwent the CAM procedure reported significant improvements in pain, range of motion, and patient-reported outcome scores, with high satisfaction and no significant complications. There was no decline in patient-reported outcomes between 5 and 10 years, other than the SANE score. With appropriate patient education concerning survivorship at minimum 10-year follow-up, the CAM procedure can play an important role in GHOA treatment when arthroplasty is not ideal or desired by the patient. Surgeon knowledge of risk factors for failure, including humeral head incongruity and osteophyte size, is also essential for patient selection.

Indications and techniques for arthroscopic treatment of GHOA range from joint lavage to debridement, loose body removal, and synovectomy. Unfortunately, the significant improvements seen from these surgical interventions were short-lived in some studies.[5,6,18,23-25] With the advancement of arthroscopic techniques, more recent techniques have shown promise for midterm sustained improvements in function for those who would like to delay arthroplasty or for whom arthroplasty is not ideal.[1,11,16,17] The current study evaluated outcomes of the CAM procedure at minimum 10-year follow-up and included glenohumeral chondroplasty, synovectomy, loose body removal, microfracture capsular release, humeral osteoplasty, axillary nerve neurolysis, subacromial decompression, and biceps tenodesis. The idea of this more extensive and comprehensive treatment of GHOA is to address as much pathology as possible, with the goal of sustained and longer-lasting improvements to delay or avoid arthroplasty.

In the longest-term studies evaluating this more extensive treatment of GHOA, similar outcomes were discovered at 5-year minimum follow-up. A total of 47 shoulders were evaluated, with 76.9% survivorship at 5 years and 26% progression to TSA at a mean 2.6 years. At a mean 5.7 years postoperatively, the mean ASES score was 84.5; SANE, 82; QuickDASH, 15; and SF-12, 51. The median patient satisfaction was 9 out of 10.[16] In the current study, with minimum 10-year follow-up, there was no significant deterioration in outcomes, other than the SANE score (73.4). The 38 shoulders had 63.2% survivorship at minimum 10-year follow-up. Outcome scores were comparable, with an ASES score of 80.6; SANE, 73.4; and QuickDASH, 17.7. Median satisfaction at 11.2 years was 7.5 of 10. This satisfaction was slightly lower than that reported at 5 years (9/10). The sustained benefit in most patients is helpful for surgeon and patient knowledge. Preoperative radiographs were also evaluated, and failure of the CAM procedure was associated with the size of the humeral head inferior osteophyte, as well as humeral head incongruity, with 93.3% of CAM failures having central flattening and severe incongruity as compared with 50% of those that survived. Although this was not evaluated at 5 years, this provides useful information as well as a grading system to educate surgeons and patients regarding potential CAM treatment longevity.

When comparing preoperative factors that predict failure, a previous study with minimum 2-year follow-up reported that treatment was more likely to fail for those who had significantly narrower preoperative joint space (1.3 mm), as well as a higher Kellgren-Lawrence grade, age >50 years, and Walch B2 or C glenoid morphology.[16] Between these 2-year results and those in the current study, only humeral head incongruity predicted failure. The smaller sample size may be one reason why these other demographic and radiographic parameters were not significantly different between the 2 groups at long-term follow-up. We believe that this novel humeral head congruity metric is likely more comprehensive and accurate than joint space measurements.

Earlier arthroscopic debridement studies reported excellent results in 80% of patients with mild arthritis but poorer outcomes when an inferior osteophyte was present.[25] Other studies also found that narrower joint space is a risk factor in failure of arthroscopic management, including Van Thiel et al[24] (1.5 vs 2.5 mm) where 22% progressed to arthroplasty at a mean 10.1 months. They concluded that risk factors for progression to arthroplasty were <2 mm of joint space, large osteophytes, and grade 4 bipolar Outerbridge changes. The higher failure rate seen in the aforementioned study as compared with that of the current study and previous CAM literature may be due to improved patient indications and the addition of extra-articular treatments (ie, axillary nerve neurolysis), as well as the relatively young and active population in the current study.

One advantage of the CAM procedure is the opportunity to address large osteophytes and perform a capsular release and axillary neurolysis. According to a recent systematic review, this is the most comprehensive treatment in the literature. The less complex arthroscopic treatments typically include lavage, debridement, and removal of loose bodies, with some performing glenohumeral ligament releases. The variability in procedures performed in the literature make comparisons difficult.[26] Previous studies showed magnetic resonance imaging evidence of teres minor atrophy in patients with GHOA, which is likely from axillary nerve impingement and may lead to posterior shoulder pain.[15] This may be one reason why more sustained relief was seen in the current study, as compared with that from more simple debridement, which leads to more long-term improvement, better motion, less pain, and sustained improved outcomes.[22]

If patients have better glenohumeral congruity, the CAM procedure has excellent survival and sustained outcomes at minimum 10 years postoperatively.

Based on this study and others, patient selection is the key for longevity of this procedure. A theoretical decision model determined that CAM was best in patients <47 years old and that those >66 years have an advantage with arthroplasty. Individualized treatment was ideal in those between 47 and 66 years of age.[23] The mean age of patients undergoing the CAM procedure in the current study was 53 years (range, 27-68 years). There was no difference in age, sex, arm dominancy, or previous surgery between the groups (treatment success vs failure). This may be due to the relatively smaller number of patients included in the study or patient indication for surgery.

In terms of arthroplasty conversion rates between the current study and others, there is a large variation as surgical technique varied greatly. A recent systematic review evaluated arthroscopic treatment of end-stage GHOA in studies with minimum 2-year follow-up.[26] It found that conversion to arthroplasty ranged from 16% to 42% at 9 to 24 months postoperatively.[8,17,23] Skelley et al[22] reported only temporary pain relief and improvement in range of motion in their series; however, their technique was limited to debridement and glenohumeral ligament release. They concluded that the benefits were likely not durable. They reported the highest failure rate, with a 42.4% rate of conversion to arthroplasty at 8.3 months. They found no correlation with pre- or intraoperative grade of GHOA and outcome scores, satisfaction, or conversion to arthroplasty.[22] Conversion to TSA in the current study was 39.5% at a mean 4.7 years and a range of 0.8 to 9.6 years. The differences between these studies and the current one include much longer follow-up as well as higher patient activity level and different surgical techniques. This makes direct comparisons difficult. In the current study, grade of GHOA was not statistically associated with CAM failure. However, in cases that failed, Kellgren-Lawrence grade was higher; glenoid wear, worse; joint space narrowing, greater; osteophyte resection, greater; microfracture, less (presumably because of more diffuse disease); and range of motion, worse. While these parameters were not statistically significant, this may be an issue of power rather than an actual finding that GHOA severity was not associated with CAM failure. With the longer-term follow-up in the current study, we believe that 63.2% survival at 10 years is a successful outcome of this typically bridging procedure in young or active patients with GHOA.

Limitations of this study include the technical complexity of the procedure, which requires an expert arthroscopist for osteophyte excision and axillary neurolysis. No serious complications were noted in these patients; however, axillary nerve injury could lead to very poor outcomes if it occurred. The patient population in the current study was also very active, with few comorbidities and high motivation to avoid arthroplasty. These unique characteristics may make these results less generalizable to all populations. The addition of a comparison group may also be helpful; however, randomization to arthroplasty or CAM was not realistic in this patient population. All patients had radiographic features that would have been an indication for arthroplasty, however. The main survivorship measure used in the current study was progression to arthroplasty, which may underestimate those who may be less satisfied with their outcome but who decided to cope rather than progress to arthroplasty. In addition, 8 eligible patients refused to participate in the study; this may have introduced selection bias and affected the survivorship, depending on the outcome in these patients. However, the patient-reported outcomes and satisfaction were high and sustained at 5 and 10 years.

CONCLUSION

This study demonstrated significant improvements in patient-reported outcomes and satisfaction at long-term follow-up in patients with end-stage GHOA who underwent a CAM procedure. Humeral head flattening and severe joint incongruity were risk factors for CAM failure, although survivorship was 63% at minimum 10-year follow-up. The CAM procedure is an effective joint-preserving treatment for GHOA and an alternative to arthroplasty in appropriately selected patients, with sustained positive outcomes at 10 years postoperatively.

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