Systematic Review

Outcomes and Survivorship After Arthroscopic Treatment of Glenohumeral Arthritis: A Systematic Review

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Purpose: To perform a systematic review of the literature describing outcomes, surgical procedures, and rates of conversion to arthroplasty after arthroscopic debridement of symptomatic primary glenohumeral osteoarthritis. **Methods:** The Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PubMed, Embase, and Ovid MEDLINE were queried. Articles without sufficiently detailed descriptions of the debridement procedure, those primarily describing cartilage resurfacing procedures, or those that did not report any postoperative outcomes were excluded. Study design, patient demographic characteristics, operative details, imaging findings, patient-reported outcomes, and rates of conversion to arthroplasty were compiled and reported. Assessment of bias was performed using the Methodological Index for Non-randomized Studies (MINORS) criteria. **Results:** A total of 371 patients (382 shoulders) in 8 studies were included. Patient sample sizes ranged from 8 patients (9 shoulders) to 98 patients (107 shoulders), and the samples were predominantly comprised of male patients (range, 57.1%-100%). The mean age and follow-up period ranged from 38 to 59 years and from 13.7 to 46.8 months, respectively. In studies reporting both preoperative and postoperative outcomes, improvements were found in American Shoulder and Elbow Surgeons scores (range, 8.6-22) and visual analog scale scores for pain (range, 0.4-3.8). There was significant heterogeneity ($I^2 = 75\%$) in the rates of conversion to shoulder arthroplasty, which ranged from 4% to 42.4%, with the mean time to conversion ranging from 9 to 56 months. Study heterogeneity improved with subgroup analyses based on minimum duration of follow-up (>2 years) and preoperative radiographic inclusion criteria. **Conclusions:** Arthroscopic treatment of glenohumeral osteoarthritis provides improvements in ROM and patient-reported outcomes with minimal complications. Despite variability in procedures and rates of subsequent conversion to arthroplasty, arthroscopic treatment appears to provide symptom relief and functional improvements in carefully selected patients. However, the longevity of improvement remains unclear, with studies including a longer duration of follow-up showing potential regression of symptom relief and increased rates of conversion to arthroplasty. **Level of Evidence:** Level IV, systematic review of Level III and IV studies.

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Pain and physical limitations caused by arthritis of the glenohumeral joint are commonly observed in active populations and individuals with prior shoulder injuries.[1] Historically, initial treatments have included activity modification, physical therapy, anti-inflammatory medications, and corticosteroid injections.[2] When symptoms of pain and physical limitations become refractory to such treatments, many patients require a joint replacement procedure such as total shoulder arthroplasty (TSA). However, in younger and more active patients, the activity restrictions and limited life span of implants are less appropriate, which has raised interest in arthroscopic temporizing procedures. These procedures are thought to provide pain relief, improve function, and delay the need for arthroplasty.[3-13]

Various arthroscopic procedures have been described in the literature, including debridement, capsular release, subacromial decompression, and simultaneous treatment of other possible contributing intra-articular pathologies.[3,8-16] The descriptions of these procedures and their outcomes, as well as arthroplasty-free survival times, vary within the literature and are largely based on retrospective case series.[3,8,12-17] Given the degree of heterogeneity in the current literature, there is a need to better understand the efficacy of the arthroscopic management of glenohumeral osteoarthritis (GHOA).

Therefore, the purpose of this study was to perform a systematic review of the literature describing outcomes, surgical procedures, and rates of conversion to arthroplasty after arthroscopic debridement of symptomatic primary GHOA. The hypothesis was 4-fold: (1) There would be significant variability with respect to the types of surgical procedures performed. (2) Significant improvements with respect to range of motion (ROM) (e.g., forward elevation [FE] and external rotation [ER]) and patient-reported outcomes (e.g., American Shoulder and Elbow Surgeons [ASES] and visual analog scale [VAS] for pain) would be observed in most studies. (3) Imaging parameters (e.g., radiography, magnetic resonance imaging, and computed tomography) and radiographic inclusion criteria would be used variably. (4) A minority of patients treated with arthroscopic debridement for GHOA would undergo conversion to arthroplasty in the reported follow-up period in each study.

Methods

Article Identification and Selection Process

A systematic search strategy was used to search the following databases in August 2019: Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PubMed, Embase, and Ovid MEDLINE. The 2009 Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) statement was used for article identification and data extraction.[18] All databases were queried using the following Boolean search terms: "shoulder OR glenohumeral" AND "arthritis OR osteoarthritis" AND "arthroscopy OR arthroscopic OR debridement." All articles (N = 7,151) appearing as part of the search were screened by 2 independent reviewers (B.T.W. and E.M.P.) with different levels of medical training (resident and medical student) for content pertaining to arthroscopic treatment of intraoperatively confirmed osteoarthritis of the glenohumeral joint. Articles were sequentially screened for duplicates, non-English language, title content, abstract content, and finally, full-text review. The references of each included article were subsequently reviewed for any articles that may have been missed in the search and screening process. The number of articles excluded with each screen was reported. A study qualified for inclusion if the article described patients with verified GHOA in whom the primary intervention was arthroscopic glenohumeral debridement. For inclusion, confirmation of articular cartilage lesions of the glenohumeral joint was required. In addition, only articles with Level I through IV evidence, written in English, and reporting outcomes (e.g., patient reported, clinical, and survivorship) were considered for inclusion. The exclusion criteria were as follows: (1) all cadaveric and animal studies (e.g., basic science, biomechanical, and anatomic); (2) imaging and technique articles without outcome data; (3) editorials, surveys, and case reports; (4) articles with inadequate descriptions of surgical procedures performed or those with significant concomitant surgical procedures (e.g., soft-tissue and bony stabilization procedures and non-shoulder procedures) or studies in which the primary surgical intervention investigated was a cartilage or resurfacing procedure (microfracture, osteochondral allograft, interposition, and so on); (5) studies describing the arthroscopic treatment of post-traumatic, inflammatory, or infectious GHOA; and (6) studies with Level V evidence or greater.

Quality Assessment

Given the inclusion of nonrandomized studies, the Methodological Index for Non-randomized Studies (MINORS) checklist was used to assess study quality.[19] The assessment tool includes 8 criteria relevant to all included studies, with an additional 4 items applicable to comparative studies. Each criterion is scored from 0 to 2, with 0 corresponding to not reported; 1, reported but inadequate; and 2, reported and adequate.[19] Comparative studies have a maximum score of 24, whereas non-comparative studies have a maximum score of 16. Given

that each included study described a single surgical intervention, all studies were scored as noncomparative. Two independent reviewers (B.T.W. and E.M.P.) assessed the methodologic quality of studies using the MINORS checklist. Discrepancies in scoring were subsequently resolved by consensus between reviewers.

Data Collection and Statistical Analysis

All data used for critical review were recorded into a custom spreadsheet using a modified information extraction table.[20] Variables of interest collected in this study included all relevant publication information, patient demographic characteristics, surgical technique, rate of and time to arthroplasty procedures, patient-reported outcome data, and clinical follow-up examination findings. The level of evidence of the studies was assigned according to the classification specified by Wright et al.[21] Patient-reported outcome data included validated tools for assessing pain and function. Within the shoulder surgery literature, these most commonly include, but are not limited to, the ASES score, VAS score for pain, Single Assessment Numeric Evaluation score, Constant-Murley score, Disabilities of the Arm, Shoulder and Hand score, Simple Shoulder Test score, University of California, Los Angeles shoulder score, and Western Ontario Osteoarthritis of the Shoulder index, as well as other general and mental health questionnaires including the Short Form 12 (SF-12) Physical Component Score and SF-12 Mental Component Score.

Given the nonrandomized design of the included studies, pooled statistics, including weighted means and standard deviations, were not reported to avoid potentially inaccurate conclusions. Study heterogeneity was assessed using the I^2 test. The I^2 measure represents the degree of variability attributed to heterogeneity rather than chance.[19] The generally accepted categorization of I^2 values for low, moderate, and high values is 25% to 49%, 50% to 74%, and 75% to 100%, respectively. Forest plots were used to graphically compare outcomes, conversion rates and effect sizes between studies. Subanalyses were performed to investigate the influence of methodologic factors contributing to study heterogeneity, including follow-up time and preoperative radiographic inclusion criteria. All statistical analyses were performed using R Project for Statistical Computing software (RStudio software, version 1.2.1335; R Foundation for Statistical Computing, Vienna, Austria).

Results

Study Characteristics

A total of 10 studies were initially identified for inclusion; however, further review determined that 3 studies came from a single center during the same reporting period. Consequently, only the most recent study with the longest follow-up period was included,[17] whereas the 2 older studies were excluded,[22,23] leaving 8 total studies meeting all inclusion criteria. Figure 1 presents a PRISMA flow diagram detailing study identification and screening. One of the eight studies reported a case-control design (Level III evidence), whereas the remaining 7 studies were retrospective case series classified as Level IV evidence. Risk of bias was assessed using MINORS criteria, with scores ranging from 5 to 13 (Table 1).

Patient Demographic Characteristics and Concomitant Procedures

A total of 371 patients (382 shoulders) were included. Patient sample sizes ranged from 8 patients (9 shoulders) to 98 patients (107 shoulders), and samples were predominantly comprised of male patients (range, 57.1%-100%). The mean age and follow-up period in the included studies ranged from 38 to 59 years and from 13.7 to 46.8 months, respectively. Five studies explicitly stated that patients underwent a nonoperative course of treatment that failed, ranging from 6 weeks to 6 months, including combinations of nonsteroidal anti-inflammatory medication, subacromial corticosteroid injection, exercise, and/or formal physical therapy.[8,13,14,16,17] All patients were treated with arthroscopic shoulder surgery including debridement of the glenohumeral joint, as well as degenerative labral tears, and removal of loose bodies and osteophytes. Other commonly performed concomitant procedures included acromioplasty, distal clavicle excision, biceps tenotomy or tenodesis,[8,15-17] humeral head osteoplasty, and axillary nerve neurolysis.[17] Four studies excluded patients who underwent a subset of concurrent procedures including any open procedures or rotator cuff or labral repairs,[3,8,15,16] whereas 1 study excluded all patients with any concomitant procedures.[14] Comprehensive details of the included studies are displayed in Table 1.

Arthroscopic Procedures for Treatment of Glenohumeral Arthritis

Descriptions of the primary arthroscopic debridement procedures varied significantly among included studies, ranging from relatively simple procedures to complex management of all potential pathology contributing to pain and limited motion. Broadly, procedural descriptions fell into 3 categories of escalating intervention. Three studies described relatively simple debridement procedures including lavage, debridement of degenerative labral and chondral lesions, loose body removal, and partial synovectomy and osteophytectomy based on individual patient pathology.[8,13,16] The next level of procedural complexity added releases of various structures such as the rotator interval and middle and inferior glenohumeral

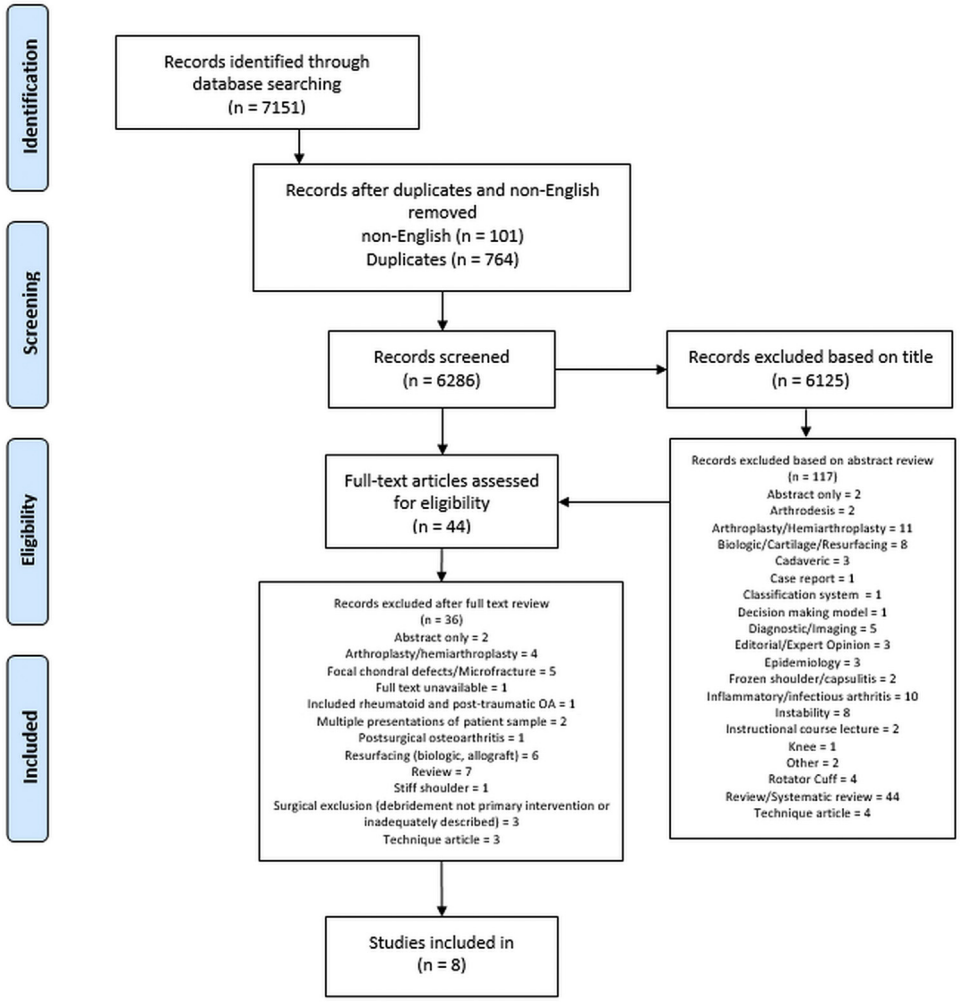

Fig 1. Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) flow diagram. (OA, osteoarthritis.)

ligaments, as well as combinations of anterior, posterior, and inferior capsular releases.[3,12,14] Finally, the most complex and comprehensive procedures frequently included all of the aforementioned elements of capsular release, with additional attention dedicated to chondral pathology, osteophyte removal aided by fluoroscopy for those on the inferior humeral head, as well as axillary nerve neurolysis.[15,17] Apart from subsequent conversion to arthroplasty, no surgical complications were reported in any of the included studies.

Imaging Techniques and Operative Cartilage Findings

Of 8 studies, 7 (87.5%) reported on preoperative radiographic findings including plain films (Table 2).[3,8,13-17] Preoperative radiographic findings included the presence of osteoarthritis (6 studies, 75%) and grading of osteoarthritis (5 studies, 62.5%) (Table 2). The radiographic joint space was measured in 2 studies (25%), with a decreased mean joint space (<2 mm) reported in groups undergoing conversion to arthroplasty.[15,17] In 1 study (12.5%), the authors commented on the Walch classification and reported a greater frequency of type B2 and C glenoids in patients who converted to arthroplasty.[17] In addition, Skelley et al.[14] reported on the presence of posterior glenohumeral subluxation (n = 14, 42.4%) and nonconcentric glenoid morphology (n = 9, 27.3%). Mitchell et al.[17] compared measurements of the critical shoulder angle in successful versus failed cases (30.2° ± 4.1° vs 27.2° ± 5.3°). All studies provided intraoperative confirmation of cartilage changes consistent with osteoarthritis, whereas only 5 (62.5%) reported specific grading distributions of intraoperative cartilage findings (Table 2).

Patient-Reported Outcome Measures

Patient-reported outcome measures (PROMs) were used preoperatively and/or postoperatively in 6 of 8 studies (75%). Two studies (25%) used 5 or more PROMs,[15,17] whereas 2 studies (25%) did not use any

Table 1. Characteristics of Included Studies

Study	Year	LOE	Inclusion Criteria	Exclusion Criteria	Patients (Shoulders), n*	% Male	Age, yr	FU, mo	Lost to FU, %†	MINORS Score
Mitchell et al.[17]	2017	III	CAM Criteria for TSA met KL grade II-IV Failure of nonsurgical management	Asymptomatic or early-stage OA No conservative management Irreparable RTC tear AVN Inflammatory arthritis Bipolar lesion HH flattening Severe joint incongruity	98 (107)	73.5	52 ± 8.6	46.8 (24-112.8)	0	12
Henry et al.[16]	2015	IV	Advanced preoperative and intraoperative GHOA	Revision surgery RCR Missing 1- and 2-yr follow-up data	56	57.1	59 ± 13	NR‡ (24-132)	33	10
Skelley et al.[14]	2015	IV	GHOA	RCR DCE SAD Bankart repair Acromioplasty Osteophytectomy Adhesive capsulitis Prior shoulder surgery	33	72.7	55.2 ± 9.2	43.4 (25-71)	0	13
Van Thiel et al.[15]	2010	IV	Preoperative and intraoperative GHOA	Adhesive capsulitis Concomitant labral repair or RCR Previous surgery within 1 yr	71	66.2	47 (18-77)	27 ± 20.1	12.3	10
Kerr and McCarty[8]	2008	IV	Age 18-55 yr Failure of nonoperative management	RTC tear	19 (20)	63.2	38 (20-54)	20 (12-33)	NR	6
Richards and Burkhart[12]	2007	IV	GHOA	NR	8 (9)	100.0	55.5 ± 12.3	13.7 ± 4.9	NR	5

(continued)

Table 1. Continued

Study	Year	LOE	Inclusion Criteria	Exclusion Criteria	Patients (Shoulders), n*	% Male	Age, yr	FU, mo	Lost to FU, %†	MINORS Score
Cameron et al.[3]	2002	IV	GHOA Outerbridge grade IV	Outerbridge grade III or lower Inflammatory or infectious arthritis Open procedure	61	67.2	49.5 (21-73)	34 (12-79)	12.9	8
Weinstein et al.[13]	2000	IV	GHOA 12 mo of FU	Grade IV radiographic findings	25	76.0	46 (27-72)	34 (12-63)	NR	5

NOTE. Data are presented as mean ± standard deviation or mean (range [minimum-maximum]) unless otherwise noted.

AVN, avascular necrosis; CAM, comprehensive arthroscopic management; DCE, distal clavicle excision; FU, follow-up; GHOA, glenohumeral osteoarthritis; HH, humeral head; KL, Kellgren-Lawrence; LOE, level of evidence; MINORS, Methodological Index for Non-randomized Studies; NR, not reported; OA, osteoarthritis; RCR, rotator cuff repair; RTC, rotator cuff; SAD, subacromial decompression; TSA, total shoulder arthroplasty.

*Data are reflective only of the number of patients (shoulders) included in the analysis and do not include patients lost to follow-up.

†The percentage lost to follow-up is reflective of patients lost to follow-up or not reachable by investigators from all eligible patients identified.

‡Data refer to follow-up of a surgical database for scheduled or performed arthroplasty procedures.

PROMs to assess clinical status after the procedures.[12,13] The most commonly reported outcome measures were the ASES score (62.5%), VAS score for pain (37.5%), and Single Assessment Numeric Evaluation score (37.5%). Three studies reported both preoperative and postoperative ASES scores, all of which showed improvements in scores at the postoperative time point (Fig 2).[14-16] The mean differences in the ASES score in each study ranged from 8.6 to 22 in patients who did not undergo conversion to arthroplasty (Fig 2) during the respective study period, which is comparable to previously published thresholds for the minimal clinically important difference in patients undergoing TSA.[24] One study (12.5%) separately reported mean improvement in patients who did and did not subsequently undergo conversion to arthroplasty, with mean ASES score improvements of 6 and 22, respectively (Fig 2).[16] Similarly, 3 studies (37.5%) reported both preoperative and postoperative VAS scores, showing decreases in the mean or median score between 0.4 and 3.8 points on the VAS.[3,14,15] Skelley et al.[14] additionally reported on trends in postoperative VAS scores, noting initial improvements early in the follow-up period, with VAS pain scores of 1 and 3.5 at 1.8 weeks and 10.6 weeks, respectively, followed by subsequent worsening of pain toward preoperative levels (mean, 7.8 preoperatively) at the final follow-up time point (mean, 173.6 weeks; VAS score, 7.4). The last PROM used for both preoperative and postoperative outcomes in the same study was the SF-12 Physical Component Score. It was only used in a single study, which noted minimal improvement from 35.9 ± 4.5 to 36.1 ± 5.5.[15] The other outcome measures and their frequency of use can be found in Table 3.

Range of Motion

All studies reported ROM data, with 6 of 8 studies (75%) reporting both preoperative and postoperative ROM,[3,12-15,17] 1 (12.5%) reporting only postoperative ROM,[8] and 1 (12.5%) reporting preoperative and postoperative active ROM on a scale of 0 to 40.[16] Of the 6 studies reporting both preoperative and postoperative values, all reported improvements in FE, with preoperative and postoperative mean ranges of 98.2° to 150° and 122.2° to 167°, respectively.[3,12-15,17] Similarly, preoperative mean ER ranged from 13.4° to 48°, improving to 28.4° to 63° postoperatively.[3,12-15,17] Furthermore, Skelley et al.[14] tracked FE and ER across multiple postoperative time points, noting initial improvement (mean, 1.8 weeks) in FE from 121.8° to 140.2° and in ER from 21.9° to 47.6°. However, these patients showed regression at the final postoperative clinic follow-up time point (mean, 16.5 weeks) to FE of 122.2° and ER of 28.4°.

Table 2. Preoperative Radiographic and Intraoperative Findings of GHOA

Study	Unipolar vs Bipolar	Preoperative Radiographic Findings*				Intraoperative Findings†			
		Grade I	Grade II	Grade III	Grade IV	Grade I	Grade II	Grade III	Grade IV
Mitchell et al.[17]	NR	NR	NR	NR	S: 25/85 (29.4%) F: 12/12 (100%)	NR	NR	NR	NR
Henry et al.[16]	NR	Advanced (joint space narrowing, humeral head osteophytes, and so on)				0	0	56 (100%)	
Skelley et al.[14‡]	Unipolar: 22 (NA: 17, A: 5) Bipolar: 11 (NA: 2, A: 9)	0	11 (33.3%)	9 (27.3%)	13 (39.4%)	0	4 (12.1%) NA: 4 A: 0	17 (51.5%) NA: 11 A: 6	12 (36.4%) NA: 4 A: 8
Van Thiel et al.[15‡]	Unipolar: 16 (NA: 14, A: 2) Bipolar: 55 (NA: 41, A: 14)			NA: 1.9 ± 0.80 A: 2.5 ± 0.81		NA: 0 A: 0	NA: 2 A: 0	NA: 16 A: 0	NA: 39 A: 16
Kerr and McCarty[8]	Unipolar: 8 Bipolar: 9	12 (63.2%)		7 (36.8%)		0	4 (21.1%)		15 (78.9%)
Cameron et al.[3]	Unipolar: 31 Bipolar: 30			33 (54.1%)		0	0	0	61
Weinstein et al.[13]	NR	5 (20%)	8 (32%)	12 (48%)	0	0	6 (24%)	11 (44%)	8 (32%)

NOTE. The study by Richards and Burkhart[12] was omitted from the table because of the absence of reporting on radiographic and intraoperative arthritis findings.
A, converted to arthroplasty; F, failed; GHOA, glenohumeral osteoarthritis; NA, did not convert to arthroplasty; NR, not reported; S, successful.
*Grades I through IV refer to Kellgren-Lawrence arthritis grades unless otherwise noted.
†The Outerbridge classification was the only specified criteria among the included articles.
‡Van Thiel et al. and Skelley et al. used Samilson-Prieto grading, with Kellgren-Lawrence arthritis grades I, II, III, and IV corresponding to Samilson-Prieto grades 0, 1, 2, and 3, respectively.

Survivorship, Reoperation, and Conversion to Shoulder Arthroplasty

Of 8 studies, 7 (87.5%) reported on survivorship and conversion to arthroplasty after arthroscopic glenohumeral debridement, with 6 (75%) reporting the time to conversion to arthroplasty. Reported arthroplasty procedures included TSA, hemiarthroplasty, and humeral head allograft.[3,12-17] The rate of conversion to arthroplasty and time to conversion to arthroplasty ranged from 4.0% to 42.4% and from 9.0 to 56 months, respectively (Table 4). The study with the longest average time to arthroplasty reported a mean time to conversion of 26 months.[16] The single longest period of survival prior to arthroplasty was 98.4 months, which was reported in the study that described the most complex, comprehensive arthroscopic management (CAM).[17] Notably, the highest rate of conversion (42.4%) and shortest mean time to conversion (9 months) were reported in the same study.[14]

Two studies (25%) reported on subsequent non-arthroplasty reoperation rates; these reoperations included 7 revision shoulder arthroscopies for debridement and 1 open biceps tenodesis.[13,17] Two studies (25%), those of Van Thiel et al.[15] and Mitchell et al.,[17] reported on factors that were associated with greater rates of conversion to arthroplasty; these included a preoperative joint space of less than 2 mm, Walch classification of type B2 or C, and age older than 50 years at the time of the index procedure.

Heterogeneity

Seven studies (87.5%) were included in the assessment of heterogeneity comparing the rate of conversion to arthroplasty after arthroscopic glenohumeral debridement (Fig 3). Effect sizes varied significantly among the included studies (4.0%-42.4%), resulting in a high degree of statistical heterogeneity ($I^2 = 75\%$). A subanalysis was performed that stratified studies based on the inclusion of patients with less than 2 years of follow-up. There were 4 studies that included any number of patients with less than 2 years of follow-up who had not undergone conversion to arthroplasty.[3,8,13,15] In these studies, conversion rates ranged from 4% to 22.5% ($I^2 = 41\%$). In contrast, there were 3 studies in which all patients who had not undergone conversion to arthroplasty had a minimum of 2 years of follow-up.[14,16,17] In these studies, the range of conversion rates was 15.9% to 42.4% ($I^2 = 73\%$) (Fig 4). In addition, a subanalysis with stratification based on preoperative radiographic criteria was performed (Fig 5). When grouping the 3 studies that included any number of patients with absent preoperative radiographic findings of arthritis (e.g., Kellgren-Lawrence grade I or Samilson-Prieto grade 0), we found a range of conversion rates of 4% to 15% ($I^2 = 0\%$).[3,8,13] In the 4 studies that only included patients with more

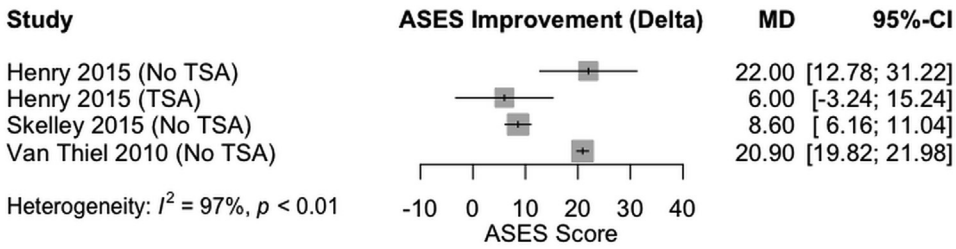

Fig 2. Preoperative to postoperative improvement (Δ) in American Shoulder and Elbow Surgeons (ASES) scores for studies in which both mean preoperative and postoperative scores were reported. The forest plot shows improvements (Δ) in ASES scores and confidence intervals (CIs) (horizontal lines). (MD, mean difference; No TSA, patients who did not undergo conversion to arthroplasty within study period; TSA, patients who underwent conversion to arthroplasty within study period.)

substantial preoperative radiographic findings (e.g., Kellgren-Lawrence grade II or greater, Samilson-Prieto grade 1 or greater, or equivalent), the range of observed conversion rates was higher, at 15.9% to 42.4% ($I^2 = 66\%$).[14-17]

Risk of Bias

Risk-of-bias assessment was performed using the MINORS criteria. Scores ranged from 5 to 13 out of a possible score of 16 for noncomparative studies. On the basis of the MINORS scoring criteria, the most common sources of possible bias were lack of blinding or an unbiased assessment of endpoints, greater than 5% loss of patients at final follow-up, and absence of any prospective calculation of study sample size.

Discussion

The most important finding of this systematic review was that most studies reported that arthroscopic treatment of GHOA and related pathology provided overall symptomatic improvement in pain and function. Specifically, most patients showed postoperative improvements in FE and ER, although 1 study suggested that these improvements may regress over time.[14] With respect to PROMs, most patients showed improvements in both pain (e.g., VAS score) and function (e.g., ASES score), which likely represent clinically significant functional improvements (e.g., minimal clinically important differences). However, the duration of symptom relief and subsequent conversion to arthroplasty varied among studies, ranging from approximately 8 weeks to 8 years, likely in part because of the heterogeneity of inclusion criteria, surgical technique, and concurrent pathologies addressed.[14,17] Significant heterogeneity was observed in the rates of conversion to arthroplasty across all studies ($I^2 = 75\%$); however, when subanalyses were performed to account for differences in follow-up time and preoperative radiographic criteria, greater agreement (reduced heterogeneity) was seen among studies. Specifically, studies with a longer duration of minimum follow-up (>2 years), as well as those that excluded patients with absent preoperative radiographic evidence of arthritis, showed higher rates of subsequent conversion.

Because of the absence of randomized studies, significant study heterogeneity and variable inclusion criteria, follow-up time, and structure of postoperative follow-up, valuable information such as pooled postoperative survivorship curves was not able to be calculated. Longitudinal survivorship at multiple time points was not routinely reported and was only explicitly reported in one of the studies identified by the initial search. Specifically, prior reports after the CAM procedure longitudinally have reported survivorship rates of 95.6% at 1 year, 86.7% at 3 years, and 76.9% at 5 years.[17,22,23] Similarly, variability across studies precluded the identification of definitive patient-specific factors predictive of failure and conversion; however, individual studies described factors such as a joint space of less than 2 mm, Walch classification of type B2 or C, and age older than 50 years at the time of the index procedure that were associated with increased rates of conversion to arthroplasty.[15,17]

The interest in arthroscopic management of GHOA has largely been motivated by patients presenting with symptomatic disease in combination with the shortcomings of arthroplasty.[25] Young patients with high activity demands often desire joint-preserving management, placing increased value on delaying arthroplasty. Our review showed that arthroscopic intervention may provide symptomatic relief of pain immediately after surgery with a minimum duration of relief of weeks to months—but potentially upwards of 2 years—while improving shoulder function.[3,14,15] However, the variability in the procedures performed and criteria for patient selection makes it difficult to identify which elements of the procedures confer the greatest benefits. The complexity of arthroscopic procedures varied significantly; however, they generally fell into 1 of 3 levels of complexity, the first being relatively simple procedures including lavage,

Table 3. Patient-Reported Outcome Measures

Outcome Characteristics	Studies
Total	8
≥5	2
3-4	1
1-2	3
0	2
Included outcomes	
ASES score	5
VAS score	3
SANE score	3
Constant-Murley score	2
SF-12 PCS	2
DASH score	1
Marx score	1
SF-12 MCS	1
SST score	1
UCLA shoulder score	1
WOOS index	1

ASES, American Shoulder and Elbow Surgeons; DASH, Disabilities of the Arm, Shoulder and Hand; MCS, Mental Component Score; PCS, Physical Component Score; SANE, Single Assessment Numeric Evaluation; SF-12, Short Form 12; SST, Simple Shoulder Test; UCLA, University of California, Los Angeles; VAS, visual analog scale; WOOS, Western Ontario Osteoarthritis of the Shoulder.

debridement of degenerative lesions, and removal of loose bodies.[8,13,16] The next level of intricacy added varying releases of the rotator interval and middle and inferior glenohumeral ligaments, as well as combinations of anterior, posterior, and inferior capsular releases.[3,12,14] Finally, the most comprehensive treatments further addressed bony, chondral, and soft-tissue pathology, describing microfracture, extensive fluoroscopically guided removal of humeral head osteophytes, and axillary nerve neurolysis.[15,17] Given that the increasing complexity of procedures was presumably accompanied by increasingly complex and possibly symptomatic patients, it becomes difficult to draw conclusions with sufficient generalizability based on available survivorship data.

Similarly to the variability in procedures performed, the indications and contraindications for arthroscopic treatment were not uniform across studies. Skelley et al.[14] reported the most selective criteria, excluding any patients requiring concomitant procedures (rotator cuff repair, distal clavicle excision, microfracture, subacromial decompression, labral repair, and osteophytectomy) and any patients with confounding pathology (adhesive capsulitis, prior rotator cuff repair, impingement, arthroplasty, hardware removal, prior capsulorrhaphy, and prior shoulder surgery). It is interesting to note that their study found that patients only reported temporary pain relief and improvement in motion immediately after the procedure, followed by regression, leading Skelley et al. to conclude that isolated arthroscopic debridement and capsular release may not provide durable benefits to support routine use in most patients. Of all the included studies, their study reported the highest rate of conversion to arthroplasty, with 42.4% of patients undergoing conversion to arthroplasty at an average of 38.4 weeks. In contrast, studies with fewer exclusion criteria, as well as those that addressed additional concurrent pathology at the time of surgery, reported more favorable PROMs and lower rates of conversion to arthroplasty.[3,8,12,13,15,17] This finding seems to suggest that improvements after arthroscopic treatment may in part be confounded by the surgical treatment of concurrent shoulder pathology.

This systematic review also identified substantial variability in both the preoperative grading and intraoperative grading of arthritis. Weinstein et al.[13] reported preoperative imaging findings showing that 13 of 25 patients had Kellgren-Lawrence grade I or II arthritis; any patient with grade IV findings was excluded. These patients had mild intraoperative Outerbridge scores (grade II, n = 6; grade III, n = 11; grade IV, n = 8) and the lowest rate of conversion to arthroplasty (4%) of any included study. The authors noted there was no correlation between radiographic grade and clinical outcomes; however, patients with higher-grade lesions intraoperatively trended toward worse clinical outcomes. In contrast, Skelley et al.[14] reported the highest rate of conversion to arthroplasty (42.4%), with an approximately even distribution of preoperative Samilson-Prieto grades (grade 1, n = 11; grade 2, n = 9; grade 3, n = 13) and a predominance of grade III or IV Outerbridge findings (grade II, n = 4; grade III, n = 17; grade IV, n = 12). After analysis, they too found no significant correlations between preoperative radiographic or intraoperative findings and subsequent VAS score, ASES score, satisfaction rating, or conversion to arthroplasty.

In attempts to identify predictors of surgical success, other studies examined preoperative radiographic

Table 4. Conversion to Shoulder Arthroplasty

	Conversion to Shoulder Arthroplasty		
Study	Total	Rate, %	Time to Conversion, mo
Mitchell et al.[17]	17	15.9	24 (5.5-98.4)
Henry et al.[16]	18	32.1	26 (13-48)
Skelley et al.[14]	14	42.4	9.0 (1.9-21.5)
Van Thiel et al.[15]	16	22.5	10.1 ± 6.41
Kerr and McCarty[8]	3	15.0	NR
Richards and Burkhart[12]	NR	NR	NR
Cameron et al.[3]	6	9.8	16.3 (2-48)
Weinstein et al.[13]	1	4.0	56

NOTE. The total number of conversions and percentage of the entire sample are presented. Times to conversion are reported as mean ± standard deviation or as mean or median (range [minimum-maximum]).

NR, not reported.

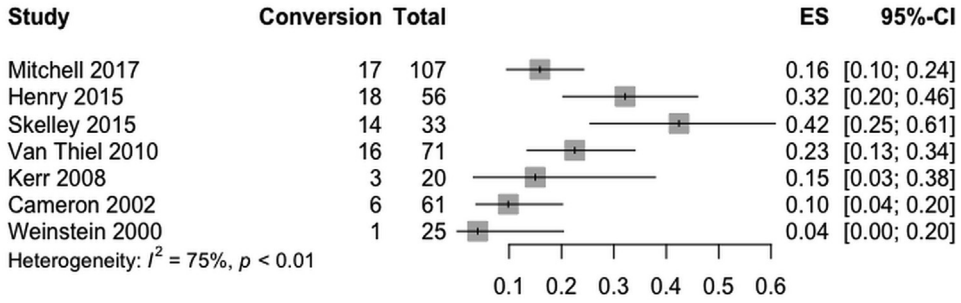

Fig 3. Rate of conversion to arthroplasty after glenohumeral debridement, with forest plot displaying effect size (ES) (arthroplasty conversion rate represented by squares, proportional in size to sample size of each study) and 95% confidence intervals (CIs) (horizontal lines).

characteristics with respect to joint space narrowing and glenoid morphology as described by the Walch classification.[26] Van Thiel et al.[15] retrospectively reviewed preoperative radiographs in a blinded fashion, showing that joint space narrowing was correlated with subsequent failure. The study by Mitchell et al.,[17] in addition to the 2 excluded studies from the same center,[22,23] corroborated the joint space threshold of 2 mm and its predictive ability with respect to subsequent conversion to arthroplasty. They also reported that a preoperative Walch classification of type B2 or C conferred an increased relative risk (6.0) of future conversion to arthroplasty. However, in this same sample, other patient factors including intraoperative findings did not appear to predict postoperative performance.[17] Although valuable, these preoperative predictive factors must be viewed in the context of the arthroscopic procedures performed and, accordingly, may lack generalizability to all patients examined in this review. Above all, this systematic review identifies the need for prospective randomized research aimed at both (1) establishing appropriate patient selection criteria and (2) defining the predictive impact of preoperative imaging (e.g., Kellgren-Lawrence grade, Walch classification, and joint space narrowing) and concurrent intra-articular pathologies (e.g., concomitant surgical procedures performed) on outcomes after arthroscopic treatment of GHOA.

Limitations

This study is not without limitations. The conclusions of this review were limited by the number of studies meeting the inclusion criteria and their respective levels of evidence, including the absence of any comparative studies or randomized trials, which precluded pooled statistics. After the exclusion of 2 of 3 studies reporting on outcomes of the same patient population, only 8 studies met the inclusion criteria. Of these studies, only 1 was not a retrospective case series. Both the number of studies and their collective level of evidence limited the strength of conclusions that could be made. Another limitation is the variability with respect to patient selection, procedures performed, concurrent pathology, and length of follow-up, which may represent confounding factors in the ability to isolate the impact of arthroscopic treatment. Examples included variability in the use of standardized radiographic scales for grading of osteoarthritis (e.g., Kellgren-Lawrence grade) and the thresholds used for including or excluding patients in individual studies. Furthermore, procedures ranged from simple debridement of degenerative labral and chondral lesions to more extensive

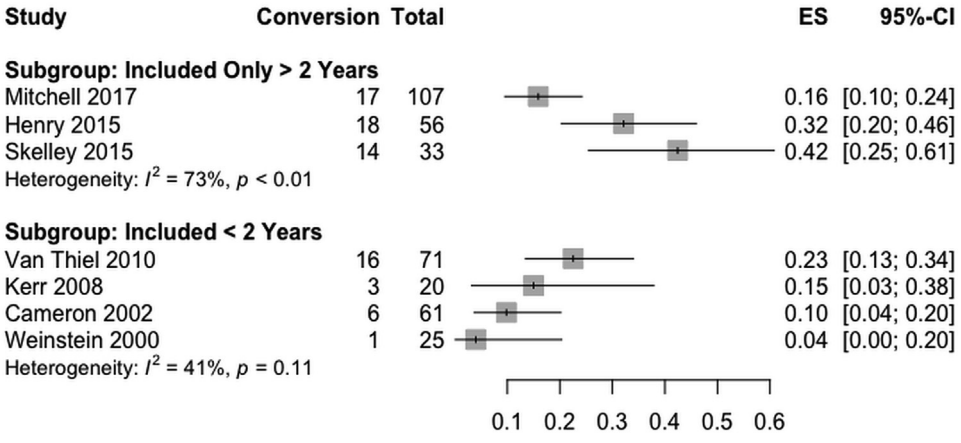

Fig 4. Rate of conversion to arthroplasty differentiated by minimum duration of follow-up, with forest plot displaying effect size (ES) (arthroplasty conversion rate represented by squares, proportional in size to sample size of each study) and 95% confidence intervals (CIs) (horizontal lines).

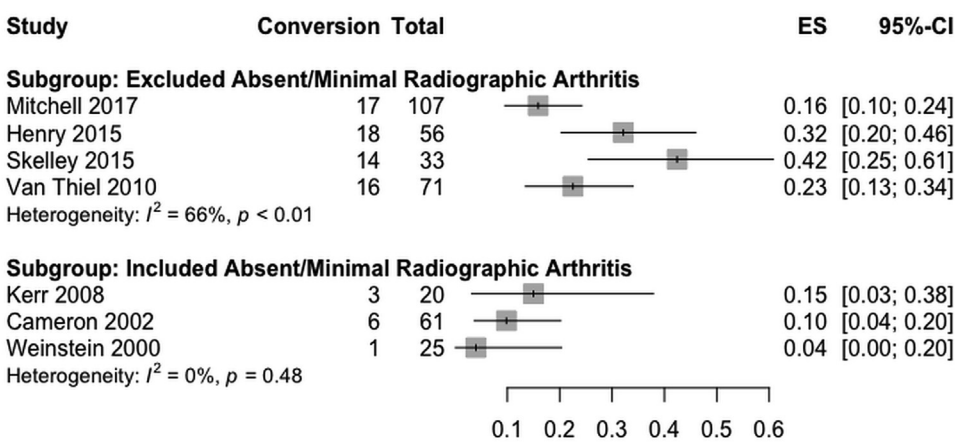

Fig 5. Rate of conversion to arthroplasty differentiated by preoperative radiographic evaluation, with forest plot displaying effect size (ES) (arthroplasty conversion rate represented by squares, proportional in size to sample size of each study) and 95% confidence intervals (CIs) (horizontal lines).

procedures including CAM.[17,22,23] In addition, some studies had no exclusion criteria and addressed many concurrent pathologies, including rotator cuff tears, SLAP tears, and biceps pathology, whereas others excluded patients with any confounding pathology addressed at the time of surgery. Finally, variability in PROM selection and physical examination data (e.g., ROM) across studies, including both the measures used and postoperative timeline of collection, limited comparisons between studies.

Conclusions

Arthroscopic treatment of GHOA provides improvements in ROM and patient-reported outcomes with minimal complications. Despite variability in procedures and rates of subsequent conversion to arthroplasty, arthroscopic treatment appears to provide symptom relief and functional improvements in carefully selected patients. However, the longevity of improvement remains unclear, with studies including a longer duration of follow-up showing potential regression of symptom relief and increased rates of conversion to arthroplasty.

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