RESEARCH ARTICLE

Evaluating Glenohumeral Osteoarthritis: The Relative Impact of Patient Age, Activity Level, Symptoms, and Kellgren-Lawrence Grade on Treatment

Adam Schumaier, MD; Joseph Abboud, MD; Brian Grawe, MD; J Gabriel Horneff, MD; Charles Getz, MD; Anthony Romeo, MD; Jay Keener, MD; Richard Friedman, MD; Ed Yian, MD; Stephanie Muh, MD; Gregory Nicholson, MD; Ruth Delaney, MD; Randall Otto, MD; William Levine, MD; JT Tokish, MD; Gerald Williams, MD; Jack Kazanjian, DO; Joshua Dines, MD; Matthew Ramsey, MD; Andrew Green, MD; Scott Paxton, MD; Surena Namdari, MD; Brody Flanagin, MD; Samer Hasan, MD; Scott Kaar, MD; Anthony Miniaci, MD; Frances Cuomo, MD

Research performed at University of Cincinnati, Department of Orthopaedics and Sports Medicine, Ohio, USA

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Abstract

Background: It is not always clear how to treat glenohumeral osteoarthritis, particularly in young patients. The goals of this study were to 1) quantify how patient age, activity level, symptoms, and radiographic findings impact the decision-making of shoulder specialists and 2) evaluate the observer reliability of the Kellgren-Lawrence (KL) grading system for primary osteoarthritis of the shoulder.

Methods: Twenty-six shoulder surgeons were each sent 54 simulated patient cases. Each patient had a different combination of age, symptoms, activity level, and radiographs. Responders graded the radiographs and chose a treatment (non-operative, arthroscopy, hemiarthroplasty, or total shoulder arthroplasty). Spearman correlations and chi square tests were used to assess the relationship between factors and treatments. Sub-analysis was performed on surgical cases. An intra-class correlation (ICC) was used to assess observer agreement.

Results: The significant correlations (*P<0.01*) were: symptoms [0.46], KL grade [0.44], and age [0.11]. In the sub-analysis of operative cases, the significant correlations were: KL grade [0.64], age [0.39], and activity level [-0.10]. The chi square analysis was significant (*P<0.01*) for all factors, but the practical significance of activity level was minimal. The ICCs were [inter](intra): KL [0.79] (0.84), patient management [0.54].

Conclusion: When evaluating glenohumeral osteoarthritis, patient symptoms and KL grade are the factors most strongly associated with treatment. In operative cases, the factors most strongly associated with the choice of operation were the patient's KL grade and age. Additionally, the KL classification demonstrated excellent observer reliability. However, there was only moderate agreement among shoulder specialists regarding treatment, indicating that this remains a controversial topic.

Level of evidence: III

Keywords: Clinical decision-making, Glenohumeral osteoarthritis, Hemiarthroplasty, Kellgren-lawrence, Patient factors, Total shoulder arthroplasty

Introduction

Arthritis is projected to affect around 18% of the U.S. population by 2020 (1). The prevalence of arthritis in the glenohumeral joint has not been defined, but shoulder arthroplasty is now the third most frequently performed joint replacement procedure (2). Despite the proven benefits of arthroplasty, it is not

Corresponding Author: Adam Schumaier, University of Cincinnati Department of Orthopaedics and Sports Medicine, Cincinnati, Ohio, USA
Email: adam.schumaier@uc.edu

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always clear which patients are appropriate candidates for shoulder arthroplasty and which patients should be treated non-operatively or arthroscopically. Further, the most suitable type of shoulder arthroplasty (total shoulder arthroplasty or hemiarthroplasty) remains debatable in certain patient populations as well (3). Evaluation and management is particularly challenging in patients who are young, highly active, or have minimal radiographic signs of glenohumeral arthritis. In young patients, some studies suggest arthroplasty leads to unsatisfactory results (4). In highly active individuals, there are concerns for prosthetic longevity (5–7). Radiographically low-grade arthritis may be more amenable to arthroscopic debridement than high-grade arthritis, but radiographic and symptom severity often do not correlate (8-12).

It is not clear which factors are most important to shoulder surgeons when deciding between non-operative management, arthroscopic treatment, or joint replacement. The goal of this study was to quantify how various patient and shoulder specific factors impact the decision-making of shoulder specialists. Secondarily, we sought to evaluate the inter and intra observer reliability of the Kellgren-Lawrence (KL) grading system and to determine if this correlates with surgeons' treatment recommendations. The researchers wanted to determine which factors were most important to shoulder surgeons when making clinical decisions, improve our ability to radiographically classify glenohumeral arthritis, and aid future research by establishing specific factors that are most relevant to surgical decision-making. The study hypotheses were that symptoms and radiographic findings would be the factors most strongly associated with treatment and that there would be good agreement on the radiographic classification of glenohumeral osteoarthritis but disagreement on the treatment.

Materials and Methods

A case-based survey study was sent to 26 practicing, fellowship trained shoulder surgeons in August and September of 2017. The survey was composed of 54 simulated cases of patients "presenting" with glenohumeral arthritis that were accompanied by shoulder x-rays. Each patient presented with a different combination of age, symptoms, and activity level. Each factor was equally represented and each specific combination occurred exactly once. The patients were either age 30, 45, or 65 years old. These ages were selected because they were felt to be sufficiently spaced out to detect the effect of age on treatment. The activity level was either low, moderate, or high. The symptoms were either mild, moderate, or severe. The vignette for symptoms and activity level are as follows:

Activity Level: [Low] inactive, very low demand with their shoulder; [Moderate] works a desk job, enjoys playing recreational basketball and lifting weights; [High] active, manual laborer

Symptoms: [Mild] only during strenuous activities; [Moderate] predominant symptoms that limit most things; [Severe] constant

To test each combination of age, activity level, and symptoms, 27 cases were required. Each of the 27 cases was then paired with either a low-grade (1 or 2) or a high-grade (3 or 4) radiograph per the Kellgren-Lawrence system, arriving at the case number of 54 total (13). There was a true anterior-posterior (AP) "Grashey" and an axillary radiograph of the glenohumeral joint provided for each case. The grade of each radiograph was agreed upon by two authors (B.N.G. and J.A.A.) prior to assigning the radiographs to patient cases.

There were 2 questions for each case. The first question asked the surgeon to grade the radiographs from 1 to 4 per the KL scale. Briefly, the classification system is graded in the following manner: Grade 1: doubtful narrowing of joint space and possible osteophytic lipping, Grade 2: definite osteophytes, definite narrowing of joint space, Grade 3: multiple osteophytes, definite narrowing of joint space, some sclerosis, and possible deformity of bone contour, Grade 4: large osteophytes, marked narrowing of joint space, severe sclerosis, and definite deformity of bone contour. No Grade 0 was included as all patients had some level of shoulder osteoarthritis. The second question asked the surgeon to choose a treatment for the patient. The 4 treatment choices were 1) non-operative [medications, injections, physical therapy, or watchful waiting], 2) arthroscopic treatment, 3) hemiarthroplasty, and 4) total shoulder arthroplasty. Throughout the survey, the surgeons were asked to assume that the rotator cuff was intact and that each patient had mild success with one attempt at non-operative care including a corticosteroid injection into the glenohumeral joint and physical therapy. The cases were randomized, so each surgeon reviewed the cases in a different order. The survey was sent a second time one month later, but for the second survey, the surgeons were only asked to grade the radiographs. This was done to calculate the intra-observer reliability for the KL grading system. The full survey is attached as a supplement.

It was assumed all 26 surgeons would complete the 54 cases, which would lead to a total number of 1,404 individual responses (26 x 54). This number of responses provides greater than 90% power to detect a moderate correlation ($r=0.4$) with an alpha of 0.05. A Spearman rs correlation coefficient and chi square test for independence were performed to quantify how the surgeons' treatment decisions were related to patient age, activity level, symptoms, and radiographic grade. The treatments were converted to an ordinal scale based on progression of care (i.e., non-operative = 1, arthroscopy = 2, hemiarthroplasty = 3, and total shoulder arthroplasty = 4) in order to calculate the Spearman correlation. The treatments were then individually correlated with age, activity level, symptoms, and radiographic grade. To assess for confounding factors, the radiographic grade was correlated with age, activity level, and symptoms. An additional sub-analysis was performed on the cases for which surgeons chose an operative intervention to correlate patient factors with the type of operation chosen. A correlation of 0 suggests no association and a correlation of 1 suggests perfect association. In this study, the spearman correlations were interpreted according to the effect sizes suggested by Cohen: [weak < 0.3]; [moderate 0.3 to 0.5]; [strong > 0.5] (14).

All 26 surveyed surgeons completed each of the 54 cases, so the inter- and intra-rater reliability was assessed using a two-way mixed agreement, single measures intra-class correlation coefficient (ICC). The ICC is similar to a weighted kappa statistic, except that it can accommodate more than two raters (15, 16). The ICC was interpreted according to Cicchetti: [poor<0.4]; [fair 0.40 to 0.59]; [good 0.60 to 0.74], [excellent >0.75] (17). All statistical tests were performed using R version 3.4.0 (R Foundation for Statistical Computing, Vienna, Austria) with RStudio version 1.0.153 (RStudio Inc, Boston, Massachusetts) (18, 19). The following R packages were used: irr (Gamer, Lemon, and Singh [version 0.84]), RVAideMemoire (Hervé [version 0.9-68]), pwr (Champely [version 1.2-1]) (20-22).

Results

The first survey, which assessed both KL grading and choice of treatment, was completed by 26 surgeons. The second survey, which assessed only KL grading for a second time in order to calculate intra-observer reliability, was completed by 22 surgeons (84.6%). The Spearman correlations for each of the patient factors and the treatment choices ranged from none to moderate [Table 1] (rs, [95% CI], *P-value*). Symptoms (0.46, [0.41 to 0.50], *P<0.001*) and KL grade (0.44, [0.40 to 0.49], *P<0.001*) had a moderate correlation, indicating that more severe symptoms and higher KL grades were more likely to result in surgical treatment decisions [Figures 1; 2]. The Spearman correlation for

Table 1. Spearman correlations for each patient factor as it relates to treatment chosen for all cases (top) and sub-analysis of operative cases (bottom)

Correlation Between Patient Factors and Treatment (Non-operative and Operative Cases, n=1404)			
	Spearmanr (95% CI)	***P-value***	**Interpretation**
Symptoms	0.46 (0.41 to 0.50)	*P < 0.001*	Moderate
KL	0.44 (0.40 to 0.49)	*P < 0.001*	Moderate
Age	0.11 (0.05 to 0.16)	*P < 0.001*	Weak
Activity	0.01 (-0.05 to 0.06)	*P = 0.81*	None
Correlation Between Patient Factors and Treatment (Sub-analysis of Operative Cases, n=813)			
	Spearmanr (95% CI)	*P-value*	**Interpretation**
KL	0.64 (0.59 to 0.68)	*P < 0.001*	Strong
Age	0.39 (0.33 to 0.45)	*P < 0.001*	Moderate
Activity	-0.11 (-0.18 to -0.04)	*P = 0.001*	Weak
Symptoms	0.02 (-0.05 to 0.09)	*P = 0.66*	None

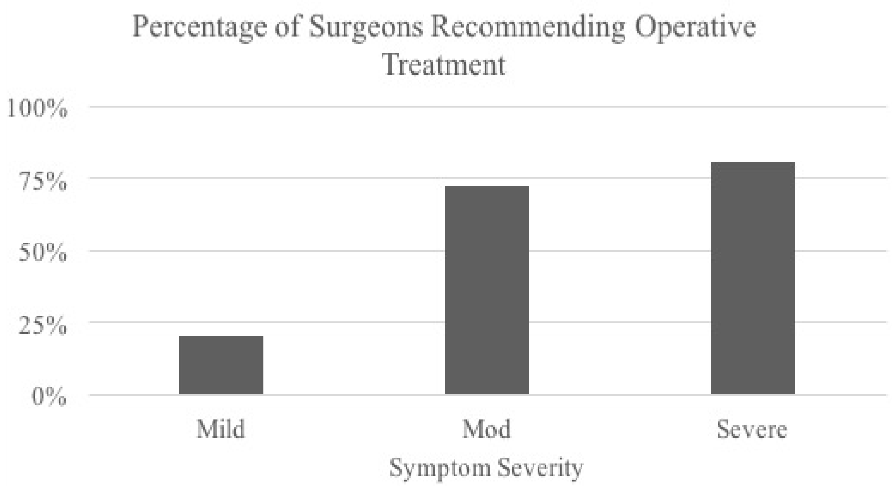

Figure 1. Percentage of cases (n=1,404) that surgeons recommended operative treatment based on the patient's symptoms.

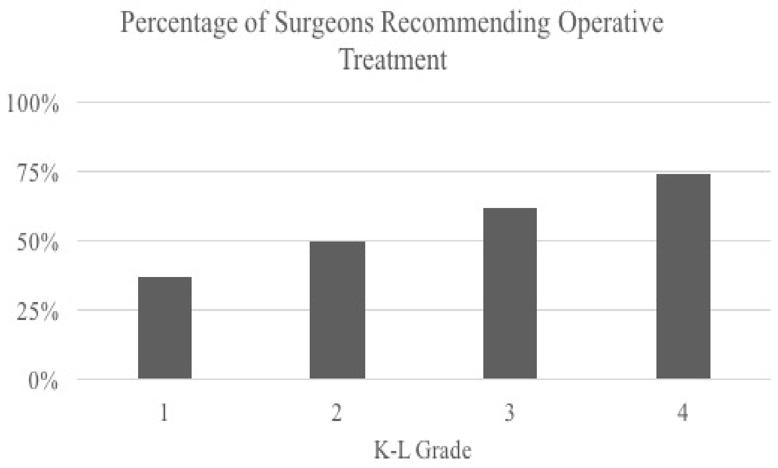

Figure 2. Percentage of cases (n=1,404) that surgeons recommended operative treatment based on the patient's KL grade.

Table 2. Frequency of treatments chosen grouped by patient factors. The p-value for each chi square test is in parenthesis

Treatment Decisions Based on Patient Specific Factors (chi-squared analysis)				
Kellgren-Lawrence (*P<0.001*)	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
Non-op	63%	50%	38%	26%
Arthroscopy	34%	38%	20%	4%
HA	0%	3%	12%	12%
TSA	3%	9%	29%	58%
Symptom Severity (*P<0.001*)	Mild	Mod	Severe	
Non-op	79%	28%	19%	
Arthroscopy	9%	25%	30%	
Hemi	2%	11%	10%	
TSA	9%	36%	40%	
Age (*P<0.001*)	.y.o 30	.y.o 45	.y.o 65	
Non-op	43%	43%	45%	
Arth	32%	22%	13%	
Hemi	16%	7%	1%	
TSA	12%	32%	44%	
Activity Level (*P=0.034*)	Low	Mod	High	
Non-op	46%	45%	40%	
Arth	18%	23%	26%	
Hemi	6%	8%	10%	
TSA	34%	28%	28%	

age had a weak correlation (0.11, [0.05 to 0.16], *P<0.01*), while the correlation for activity level was very low and statistically insignificant (0.01, [-0.05 to 0.06], *P=0.98*).

In the sub-analysis of cases where operative treatment was chosen (n=813) [Table 2], the correlations were moderate for KL grade (0.64, [0.59 to 0.68], *P<0.001*)

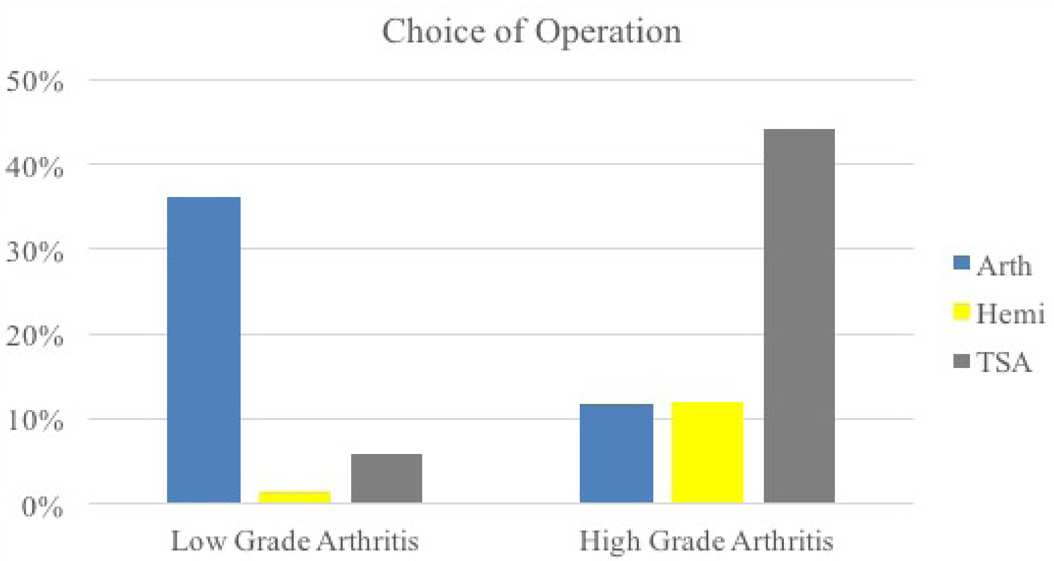

Figure 3. Sub-analysis of operative cases (n=813): percentage of cases that surgeons recommended arthroscopy, hemiarthroplasty, or total shoulder arthroplasty based on the patient's KL grade (low grade= KL 1-2, high grade = KL 3-4).

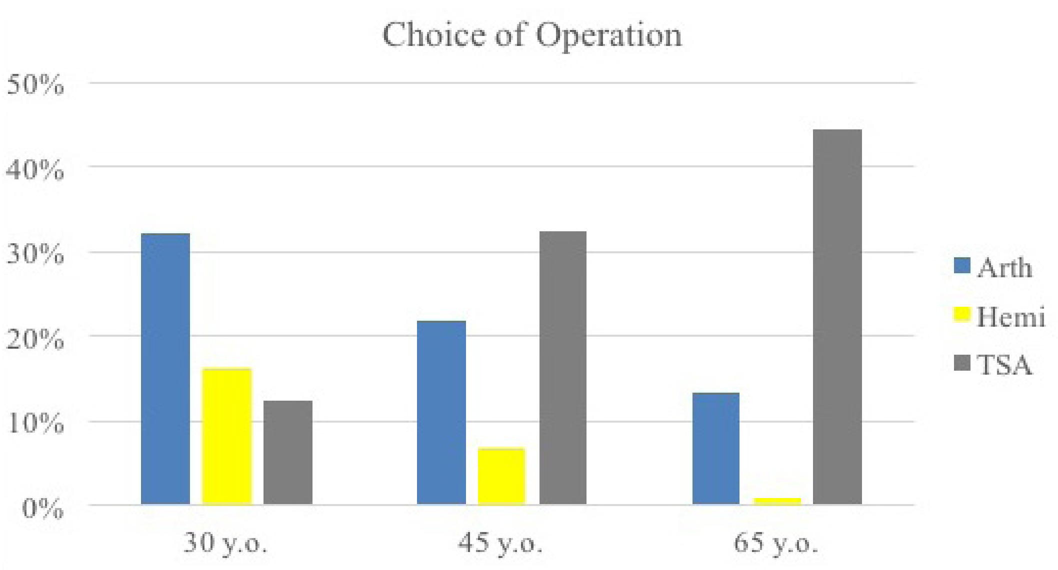

Figure 4. Sub-analysis of operative cases (n=813): percentage of cases that surgeons recommended arthroscopy, hemiarthroplasty, or total shoulder arthroplasty based on the patient's age.

and age (0.39, [0.33 to 0.45], *P<0.001*), indicating that higher KL grades and older age were more likely to result in escalation of surgical treatment [Figures 3; 4]. The correlation between surgical treatment and activity level was weakly negative (-0.11, [-0.18 to -0.04], *P=0.001*) and was not statistically significant for symptoms (0.02, [-0.05 to 0.09], *P=0.66*). The chi squared independence tests for each of the patient factors as related to all treatment options was statistically significant (activity, *P=0.034*; age, *P<0.001*; KL, *P<0.001*; symptoms, *P<0.001*), but the practical significance was minimal for activity level [Table 2].

In total, 1,404 radiographs were graded from the first survey (KL 1 [280], KL 2 [288], KL 3 [410], KL 4

Table 3. Intra-class correlation coefficients for the inter- and intra-observer reliability of the KL grading system and the .inter-observer agreement for treatments

Inter and Intra Observer Reliability of Survey Responders (n=26[responders], n=1404[cases])			
	ICC (95% CI)	*P-value*	Interpretation
Radiographic Grading (Inter)	0.79 (0.72 to 0.85)	*P < 0.001*	Good to Excellent
Radiographic Grading (Intra)*	0.84 (0.82 to 0.85)	*P < 0.001*	Excellent
Treatment Choices (Inter)	0.54 (0.44 to 0.65)	*P < 0.001*	Fair to Good

*n=22[responders], n=1188[cases]

[426]). In total, 1,188 radiographs were graded from the second survey (KL 1 [232], KL 2 [244], KL 3 [346], KL 4 [366]). For the assessment of confounding factors, there was no significant correlation with radiographic grade and age (*P=0.45*), activity level (*P=0.21*), or symptoms (*P=0.35*). The ICC to assess the inter-observer reliability for KL grading was 0.79 [0.72 to 0.85, *P<0.001*] and intra-observer reliability was 0.84 [0.82 to 0.85, *P<0.001*]. The ICC to assess inter-observer agreement of treatment choices was 0.54 [0.44 to 0.64, *P<0.001*] [Table 3].

Discussion

Osteoarthritis of the glenohumeral joint can cause significant pain and disability (23). Deciding how to treat patients can be difficult, especially those who are young and highly active (24). Age, activity level, symptoms, and radiographic signs of arthritis are commonly used to evaluate this condition (25). The goal of our study was to quantify how each of these factors influences the surgeon's choice of non-operative management, arthroscopic treatment, and arthroplasty.

Age

Treatment of glenohumeral arthritis in the young and middle-aged patient is a controversial topic (25–27). The young patient often presents with arthritis secondary to other conditions besides primary osteoarthritis, has higher expectations, and is more likely to eventually experience implant failure (28). Most authors recommend non-operative management (24, 26, 29). Interestingly, our study found that the rates of non-operative management were nearly identical in all age groups. Age was only slightly correlated with management (rs=0.12), but age had a much more significant role in the choice of operation (rs=0.39), as surgeons favored arthroscopy in younger patients. Arthroscopy is useful as a joint preserving treatment that can identify and address conditions like biceps pathology or labral disease (27). There are studies suggesting arthroscopy can reduce pain and prevent arthroplasty, particularly in patients with earlier stage radiographic arthritis (8, 9, 30). This makes such treatment an attractive option for young patients. However, the results of arthroscopic treatment may be inferior for patients with less than 2 mm of joint space remaining (31, 32).

Among cases where joint replacement was selected for the youngest age group in our study, hemiarthroplasty was slightly favored over total shoulder arthroplasty. Hemiarthroplasty could be favored in the young patient because it theoretically offers a degree of glenoid preservation; however, studies suggest it is inferior to total shoulder replacement in terms of pain relief and restoring range of motion with a higher rate of revision (33, 34). Appropriate patient selection for hemiarthroplasty and total shoulder arthroplasty is paramount, as later conversion from hemiarthroplasty to total shoulder arthroplasty may be less successful than a primary total shoulder arthroplasty (35, 36). As well, most published studies investigating hemiarthroplasty and total shoulder arthroplasty in young patients include patients who are mostly near 50 years of age, and it is unclear if the conclusions in these studies can be extrapolated to much younger patients (37–42). From a cost-analysis perspective, an economic decision model by Bhat et al. that also evaluated quality-adjusted-life-years favored total shoulder arthroplasty over hemiarthroplasty in patients who are 30 to 50 years old with glenohumeral arthritis (43). Still, it is unclear if joint preservation with hemiarthroplasty is more successful than total shoulder replacement in the long-term, which likely explains why these procedures were selected at roughly equal rates for the young patients in our study. This is in contrast to the older patients in which total shoulder arthroplasty was clearly favored when a surgical solution was chosen.

Activity Level

Activity level is thought to be an important factor for determining the treatment of glenohumeral arthritis due to the risks associated with implant longevity and component loosening (24, 27, 28, 44). Interestingly, this was the least significant factor in our study with an rs of 0.007. There was a slight negative correlation (rs=-0.1) when analyzing only the cases where operative management was recommended, which indicates that as patients became more active, surgeons were slightly more likely to recommend arthroscopy or hemi arthroplasty compared to total shoulder arthroplasty. Given that the humeral component tends to have satisfactory longevity at long-term follow-up, the decision for hemiarthroplasty over total shoulder arthroplasty could be due to concerns for longevity of the glenoid component in a total shoulder arthroplasty (44, 45).

Symptoms

Symptoms are an important factor in treating any patient, and it is not surprising that this was the factor most strongly correlated with management (rs=0.46). However, symptom severity was not important for deciding what type of operation to choose in the surgical cases (rs=0.02). This demonstrates that the subjective description of symptoms is most important for indicating a patient for surgical treatment, but more objective variables such as radiographic grade of arthritis and age are most important for determining the type of surgery performed.

Radiographic Grade

There are multiple classification systems that have been used for classifying glenohumeral arthropathy with plain radiographs. There is the Samilson and Prieto with Allain and Gerber modifications, Weinstein, Guyette, and KL classifications (30, 46-51). A 2013 study by Elsharkawi included two observers and found excellent inter- and intra-observer reliability with all of these classifications (51). The authors provide a thorough description of each classification (51). In general, each classification assesses osteophytes, joint space narrowing, and sclerosis. We chose the KL classification because it is the most widely used system for classifying arthritis (52, 53). Although it was not originally applied to the glenohumeral joint, the radiographic findings of arthritis are reasonably consistent across most joints, including the shoulder (with the exception of posterior wear) (13, 54).

We found excellent inter- and intra-observer agreement for the KL classification system. Further, it was moderately correlated with patient management (rs=0.44) and had the strongest correlation with choice of operation in the surgically treated cases (rs=0.64). This suggests that it was the only factor that was important for both deciding to operate and which type of operation to perform. Multiple studies have shown that low radiographic grade is an important factor in the success of arthroscopic management of glenohumeral arthritis (8, 9, 30, 55). In support of these studies, we found that surgeons preferred arthroscopy for grade 1 and 2 arthritis. There was little consensus for treating grade 3 arthritis, which had a broad distribution of non-operative management (39%), arthroscopy (20%), hemiarthroplasty (12%), and total shoulder arthroplasty (29%). This could be due to the limitations of grading arthritis on radiographs. Some studies have reported patients with higher grade chondral lesions that do well with arthroscopy, but these lesions may not be associated with detectable radiographic arthritis (8, 56, 57). Additionally, the location, size, and polarity of arthritic lesions can determine if the patient is a good candidate for arthroscopic debridement, but these features are not captured well by the currently used x-ray based classifications.

Limitations

This study has several limitations. While multiple fellowship-trained shoulder surgeons were surveyed, these respondents may not generalize to all practice environments. The question still remains as to what is considered a “young” patient. One must consider a threshold for which a total shoulder arthroplasty is overwhelmingly chosen as the surgical treatment option. Any patient under this threshold would therefore be considered “young.” Our study suggests the age of 40-45 years as a breaking point for which surgeons chose total shoulder arthroplasty as the surgical treatment of choice. However, we only chose arbitrary ages to evaluate. Future studies are needed to determine the threshold for what is considered a “young” patient with arthritis to help guide treatment recommendations. Also, it is clear that variables other than age, activity level, symptom severity, and radiographic findings can contribute substantially to treatment decisions; this may partially explain the variable agreement amongst the surgeons surveyed. Despite this, these variables were selected by consensus of a group of expert shoulder surgeons as the most likely to influence decision-making. Finally, while the intra-observer reliability of the KL classification system was calculated, the intra-observer reliability of treatment decisions was not determined.

When evaluating glenohumeral arthritis, patient symptoms (rs=0.46) and KL grade (rs=0.44) are the factors most strongly correlated with the management decisions of shoulder specialists. In cases that were treated surgically, the factors most strongly correlated with the choice of operation were the KL grade (rs=0.64) and age (rs=0.39). Additionally, we found that the KL classification has excellent inter and intra-observer reliability for classifying glenohumeral arthritis. While this study highlights some of the factors that are important in dictating treatment decisions for glenohumeral osteoarthritis, there was only moderate agreement among shoulder specialists, indicating either limitations in our study methodology or variability in treatment philosophies among surgeons. This underscores the lack of high quality evidence to guide the treatment of younger patients with glenohumeral osteoarthritis.

Adam Schumaier MD
Brian Grawe MD
University of Cincinnati Department of Orthopaedics and Sports Medicine, Cincinnati, Ohio, USA

Joseph Abboud MD
J Gabriel Horneff MD
Charles Getz MD
Gerald Williams MD
Matthew Ramsey MD
Surena Namdari MD
Rothman Institute, Thomas Jefferson University, Philadelphia, Pennsylvania, USA

Anthony Romeo MD
Gregory Nicholson MD
Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, USA

Jay Keener MD
Department of Orthopaedic Surgery, Washington University in St. Louis, St. Louis, Missouri, USA

Richard Friedman MD
Department of Orthopaedic Surgery, Medical University of South Carolina, Charleston, South Carolina, USA

Ed Yian MD
Department of Orthopaedics, Southern California Permanente Medical Group, Anaheim, California, USA

Stephanie Muh MD
Department of Orthopaedic Surgery, Henry Ford Hospital, Detroit, Michigan, USA

Ruth Delaney MD
University College Dublin, Dublin, Ireland

Randall Otto MD
Premier Care Orthopaedics and Sports Medicine, St. Louis, Missouri, USA

William Levine MD
Department of Orthopaedic Surgery, Columbia University Medical Center, New York, New York, USA

JT Tokish MD
Steadman Hawkins Clinic of the Carolinas, Greenville Health System, Greenville, South Carolina, USA

Jack Kazanjian DO
Premier Orthopaedics, Havertown, Pennsylvania, USA

Joshua Dines MD
Hospital for Special Surgery, New York, New York, USA

Andrew Green MD
Scott Paxton MD
Department of Orthopaedic Surgery, Warren-Alpert School of Medicine at Brown University, Providence, Rhode Island

Brody Flanagin MD
Orthopaedic Associates of Dallas, Dallas, Texas, USA

Samer Hasan MD
Cincinnati Sports Medicine, Cincinnati, Ohio, USA

Scott Kaar MD
Department of Orthopaedic Surgery, Saint Louis University, St. Louis, Missouri, USA

Anthony Miniaci MD
Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, Ohio, USA

Frances Cuomo MD
Department of Orthopaedic Surgery, Montefiore, New York, New York, USA

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