Journal of Shoulder and Elbow Arthroplasty
Volume 6: 1–7

DOI: 10.1177/24715492221075446
journals.sagepub.com/home/sea
SAGE

Clinical Fate of Glenohumeral Osteoarthritis Following Intraarticular Corticosteroid Injection: An Analysis in 311 Shoulders

H. Mike KimMD[1], Maaz MuhammadBS[1], Sally D. HeilBS[1] and Matthew J. SmithMD[1]

Abstract

Background: Intraarticular corticosteroid injection is commonly used conservative treatment for glenohumeral osteoarthritis (OA). The purpose of this study was to investigate the clinical fate of symptomatic glenohumeral OA following intraarticular corticosteroid injection and to identify factors associated with undergoing shoulder arthroplasty.

Methods: Glenohumeral OA patients who had undergone at least one glenohumeral corticosteroid injection from 2012 to 2017 were identified. Data for demographics, comorbidities, number of injections, severity of radiographic arthritis, and subsequent treatment were collected up to February 2020. Data were analyzed to compare between patients who had eventually undergone shoulder arthroplasty and those who had not.

Results: A total of 311 shoulders (275 patients) were followed up for 3 to 8 years after the index injection. The mean age of patients was 64.7 years. There were 148 females, and 116 shoulders (37.3%) eventually underwent arthroplasty, 68 (21.9%) further injections only, 104 (33.4%) no further treatment, 14 (4.5%) a non-arthroplasty surgical procedure, and 9 (2.9%) were lost to follow up. Severity of radiographic arthritic changes, female sex, younger age, and nonsmoking status were found to be significantly associated with undergoing arthroplasty ($p < 0.001$, $p = 0.014$, $p = 0.003$, and $p = 0.043$, respectively).

Conclusion: Approximately one third of glenohumeral OA patients who had received an intraarticular corticosteroid injection eventually elected to undergo shoulder arthroplasty within 3 to 8 years of the injection. High-grade arthritic changes in radiographs, female gender, and younger age were found to be independent factors associated with undergoing arthroplasty. This information may be useful in counseling patients about their future clinical course. Level of Evidence: Level III Retrospective comparative study

Keywords

glenohumeral osteoarthritis, corticosteroid, intraarticular injection, shoulder arthroplasty, natural history, arthritis grading

Received 9 September 2021; Revised received 4 November 2021; accepted 5 January 2022

Introduction

The glenohumeral joint is the third most common large joint affected by degenerative joint disease following the knee and hip joints.[1] Conservative management is the mainstay of initial treatment of glenohumeral osteoarthritis (OA) and includes activity modification, physical therapy, anti-inflammatory medications, and intraarticular corticosteroid injection. For patients who failed conservative treatment, surgical options are considered such as arthroscopic debridement[2] and shoulder arthroplasty. The decision to undergo shoulder arthroplasty is based on multiple factors, which are dynamically influenced by both patients and treating physicians. Glenohumeral intraarticular corticosteroid injection is one of the most commonly used conservative treatment modalities for symptomatic glenohumeral OA,[3] but there is a paucity of information in the current literature regarding the efficacy of these injections. Presently, physicians who treat glenohumeral OA patients are not well

[1]Missouri Orthopaedic Institute, University of Missouri, Columbia, MO 65212, USA

Corresponding Author:
H. Mike Kim, MD, Missouri Orthopaedic Institute, University of Missouri, 1100 Virginia Avenue, Columbia, MO, 65212, USA.
Email: kimhm@health.missouri.edu

informed about the natural history of glenohumeral OA that is symptomatic enough to be considered for intraarticular corticosteroid injections. There is little information about how likely it is that patients receiving an injection will end up having shoulder arthroplasty in the future and what are the factors that **are associated with** that likelihood. Having this information at the time of the initial discussion about treatment options can be helpful to both patients and physicians.

The purpose of this study was to investigate the **clinical course of glenohumeral OA** following intraarticular corticosteroid injections **especially in relation to the likelihood of undergoing shoulder arthroplasty** and to determine factors that are associated with undergoing shoulder arthroplasty. To this end, we conducted a retrospective cohort study where the clinical courses of a group of patients meeting selection criteria were followed up longitudinally in their medical records. We hypothesized that a high proportion of patients would eventually undergo shoulder arthroplasty for their definitive treatment and that the radiographic severity of arthritis would positively correlate with the decision to receive shoulder arthroplasty.

Materials and Methods

Study Subjects

After obtaining an approval from the Institutional Board Review, the department billing database was searched to identify all clinic visits where a glenohumeral intraarticular corticosteroid injection had been performed either without imaging guidance, or under ultrasound or fluoroscopic guidance at our institution between 2012 and 2017 for primary glenohumeral OA. The physicians who performed injections during the 5-year period included two physiatrists, two sports medicine family physicians, two musculoskeletal radiologists, and one shoulder and elbow surgeon. The two radiologists performed injections only on patients who were referred to them for injections, while all other physicians independently diagnosed patients and performed the injections. All clinic visits that had a CPT code for a large joint injection with (20611) or without (20610) ultrasound guidance, or joint injection under fluoroscopic guidance (20610 + 77002) in patients who had one of the ICD-9 codes (712.91, 715.11,715.31, 716.61, 716.81, 716.91, 718.01, 719.81) or ICD-10 codes (M19.019, M19.011, M19,012, M12.819, M12.9, M24.119) were searched. Individual clinic visit records were reviewed to include only intraarticular corticosteroid injections done for glenohumeral OA. Injections done to other joints (eg, hip, knee, ankle), those done to a different shoulder structure other than the glenohumeral joint (eg, acromioclavicular joint, subacromial bursa, bicipital sheath), and those done using a different drug other than corticosteroid (eg, hyaluronate) were excluded. Glenohumeral intraarticular corticosteroid injections done for a different condition other than primary glenohumeral OA (eg, cuff tear arthropathy, adhesive capsulitis, labral tear) were also excluded. The medical record of the patients who had met all these criteria were further reviewed to collect the following information: age, gender, laterality, hand dominance, body mass index (BMI), obesity, smoking status, occupation, comorbidities, and Charlson Comorbidity index[4] at the time of injection. The clinical course of each patient after the index injection was tracked until February 2020. Each patient's medical record was reviewed to see if the patient had received further intraarticular corticosteroid injections or had undergone any surgical procedures (eg, arthroplasty, arthroscopic procedures). If the clinical course of a patient could not be tracked in the medical record, the patient was contacted over the phone to collect the relevant information. Shoulder x-rays of each patient taken within a year of the index injection were reviewed by the senior author for radiographic grading of glenohumeral OA based on the Samilson and Prieto classification system.[5] The senior author was blinded to the patient's clinical courses. This system has three grades. Grade 1 depicts osteophytes smaller than 3 mm at the inferior humeral head and/or glenoid, Grade 2 osteophytes sized between 3 and 7 mm at the inferior humeral head and/or glenoid with slight glenohumeral joint irregularity, and Grade 3 osteophytes larger than 7 mm at the inferior humeral head and/or glenoid with narrowing of the joint and sclerosis.

Data Analysis

Data were analyzed using both descriptive and inferential statistics. We obtained the rate of undergoing shoulder arthroplasty in patients who had received at least one intraarticular corticosteroid injection to the glenohumeral joint within the follow-up period. To investigate the differences between patients who had undergone shoulder arthroplasty and those who had not, data were compared between the two groups using X^2 test for categorical variables and unpaired t-test for interval and continuous variables. Binary logistic regression analysis was performed to identify independent risk factors for undergoing shoulder arthroplasty. The statistical significance was set at $p < 0.05$. The data were presented in mean ± standard deviation. No adjustment for multiple statistical comparisons was performed as each comparison tested a different hypothesis.

Results

The initial departmental billing database search yielded a list of 621 clinic visits (455 patients) (Figure 1). The subsequent medical record review resulted in an exclusion of 167 visits because the injection of interest had been done to a different joint other than the shoulder. Among the remaining 454 visits, 102 visits were excluded because the injection had

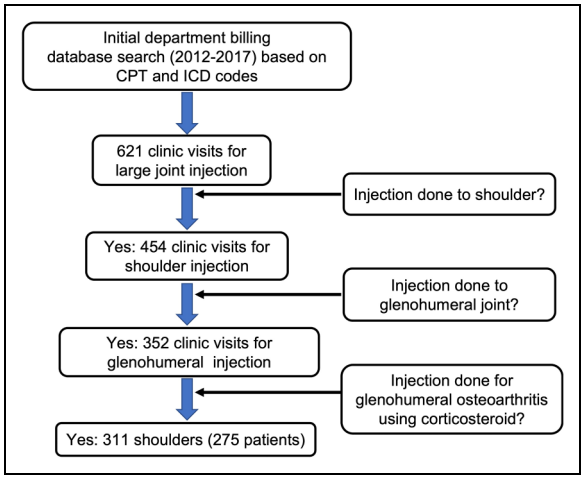

Figure 1. Patient selection flowchart.

been done to a structure other than the glenohumeral joint; 63 visits were for a subacromial injection, 38 for an acromioclavicular joint injection, and one for a bicipital sheath injection. Of the remaining 352 visits, 27 visits were excluded because the intraarticular injection was done for a different condition other than glenohumeral osteoarthritis; 11 for cuff tear arthropathy, eight for adhesive capsulitis, two for postoperative stiffness, one for chronic glenohumeral dislocation, one for post-hemiarthroplasty pain, three for nonspecific glenohumeral joint pain without a confirmed diagnosis, and one for joint aspiration without a corticosteroid injection. Lastly, 16 visits were excluded because the intraarticular injection used a different drug other than corticosteroid; 13 used Euflexxa, one Monovisc, one Synvisc, and one Marcaine only.

Ultimately, a total of 311 shoulders (275 patients) were confirmed to have a glenohumeral intraarticular corticosteroid injection for a diagnosis of primary glenohumeral OA. The mean age of the 275 patients was 64.7 ± 12.6 years (range 31-98 years). There were 127 males (46.2%) and 148 females (53.8%). The characteristics of the 311 shoulders is summarized in Table 1.

With regard to clinical courses of the 311 shoulders following the index injection, 116 (37.3%) shoulders eventually underwent arthroplasty, 68 (21.9%) received further injections without surgical procedures, 104 (33.4%) received no further treatment, 14 (4.5%) received a surgical procedure other than arthroplasty, and 9 (2.9%) were lost to follow up. The nine shoulders (seven patients) that were lost to follow up had no medical record that could confirm their eventual clinical course and could not be reached for a phone interview despite multiple attempts. The 116 shoulders who eventually underwent arthroplasty received on average 2 (range 0 to 8) additional injections before their arthroplasty. Among them, 87 shoulders underwent anatomic total shoulder arthroplasty, 22 reverse shoulder arthroplasty, and seven hemiarthroplasty.

Table 1. Characteristics of the 311 Eligible Shoulders That Received at Least one Intraarticular Glenohumeral Corticosteroid Injections During the Study Period from 2012 to 2017.

Dominant side involvement	Yes: 115 (37.0%) No: 119 (38.2%) Missing: 77 (24.8%)
Clinical course following index injection	Arthroplasty: 116 (37.3%) Further injections only: 68 (21.9%) Other procedures: 14 (4.5%) No further treatment: 104 (33.4%) Lost to follow-up: 9 (2.9%)
Arthritis grading	Grade 1: 94 (30.2%) Grade 2: 78 (25.1%) Grade 3: 138 (44.4%) Missing x-rays: 1 (0.3%)
Obesity	Normal: 149 (47.9%) Obesity: 102 (32.8%) Morbid Obesity: 60 (19.3%)
Total number of injections during study period	Mean: 2.2 ± 2.6 (range 1-17)
Kinds of corticosteroid used	Triamcinolone acetonide (Kenalog): 210 Triamcinolone hexacetonide (Aristospan): 52 Methylprednisolone diacetate (Depo-Medrol): 39 Not specified: 10

In comparison between the shoulders that ultimately underwent shoulder arthroplasty (Arthroplasty group) and those that did not undergo shoulder arthroplasty (Non-arthroplasty group) (Table 2), arthritis grading based on the Samilson and Prieto classification was significantly different between the groups. There was a significantly higher proportion of shoulders with grade-3 arthritis in the Arthroplasty group than in the Non-arthroplasty group ($p = < 0.001$). There was a higher proportion of female patients (60%) in the Arthroplasty group than in the Non-arthroplasty group (51%), but this difference was not statistically significant ($p = 0.116$). Similarly, there was a higher proportion of patients who had never smoked (63%) in the Arthroplasty group than in the Non-arthroplasty group (51%), but this difference was not statistically significant ($p = 0.061$). All other variables – age, dominant side involvement, bilateral shoulder involvement, occupation, BMI, obesity, and Charlson comorbidity index – showed no significant differences between the two groups ($p > 0.05$).

With logistic regression analysis, gender, age, arthritis grades, and smoking status were found to be significant independent predictors of undergoing arthroplasty after controlling for other variables (Table 3). With regard to gender, female patients had 2.4 times higher odds of undergoing arthroplasty than male patients ($p = 0.014$). Being younger by 1 year increased the odds of undergoing arthroplasty by

Table 2. Comparisons Between Shoulders That Underwent Arthroplasty and Those That did not (After Excluding the Patients who Were Lost to Follow up): N = 302.

	Arthroplasty (116)	No arthroplasty (186)	p-value
Age	63.4 ± 10.7	65.9 ± 13.3	0.0981*
Sex	Female 70 Male 46	Female 95 Male 91	0.116†
Dominant side involvement	No 43 Yes 50 Missing 23	No 72 Yes 62 Missing 52	0.150†
Injection number	2.17 ± 2.06	2.17 ± 2.91	0.9886*
Bilateral shoulder involvement	No 102 Yes 14	No 166 Yes 20	0.725†
Occupation	Unemployed 2 Disabled 20 Retired 45 Sedentary 20 Manual type 21 Missing 8	Unemployed 7 Disabled 35 Retired 79 Sedentary 26 Manual type 25 Missing14	0.717†
Arthritis grading	Grade 1 19 Grade 2 31 Grade 3 66 Missing 0	Grade 1 74 Grade 2 44 Grade 3 67 Missing 1	0.000†
BMI	33.8 ± 8.3	32.8 ± 8.9	0.314*
Smoking	Never 73 (63%) Former 32 (28%) Current 11 (9%) Missing 0	Never 94 (51%) Former 57 (30%) Current 31 (17%) Missing 4 (2%)	0.061†
Obesity	No 45 Obesity 42 Morbid obesity 25 Missing 4	No 85 Obesity 57 Morbid obesity 33 Missing 11	0.410†
Charlson Comorbidity index	3.96 ± 2.07	4.13 ± 2.39	0.542*

*p-value derived from unpaired t-test.
†p-value derived from X^2 test.

a factor of 1.06 (p = 0.003). With regard to arthritis grades, patients with grade-3 arthritis had 7.8 times higher odds of undergoing arthroplasty than those with grade-1 arthritis (p < 0.001). With regard to smoking status, patients who had never smoked had 4.5 times higher odds of undergoing arthroplasty than those who were smoking at the time of injection (p = 0.012). All other variables – dominant side involvement, the number of injections, occupation, BMI, and obesity – were found to have no significant influence in predicting subsequent arthroplasty (p > 0.05).

Discussion

The present study found that 37.3% of shoulders that had received a glenohumeral intraarticular corticosteroid injection for primary glenohumeral OA went on to shoulder arthroplasty within 3 to 8 years of the injection. When considering the percentage of shoulders that received a surgical procedure other than arthroplasty (4.5%), approximately 42% patients went on to a surgical procedure. To our knowledge, there are no previous studies in the shoulder literature that we can compare our result with. The literature regarding hip arthritis had a few studies that investigated the efficacy of corticosteroid injections. Lai *et al.*[6] followed 78 patients who had received intraarticular corticosteroid hip injections and found that 48.7% of the patients eventually underwent hip arthroplasty within 2 years of the initial injection. One other study found that at 42 months after a therapeutic hip injection, 70% of patients went on to hip arthroplasty.[7]

In our study, radiographic severity of osteoarthritis at the time of injection was found to be a significant predictor of undergoing arthroplasty in the future. Fifty percent of the shoulders with grade-3 arthritis received arthroplasty, whereas 20% of those with grade-1% and 41% of those with grade-2 arthritis received arthroplasty (Figure 2). Patients who had grade-3 arthritis had 7.8 times higher odds of undergoing arthroplasty than those with grade-1 arthritis. The literature shows a similar finding with hip injections, but no studies have been done on glenohumeral

Table 3. Binary Logistic Regression Analysis to Identify Factors That Significantly Contribute to the Risk of Undergoing Shoulder Arthroplasty in Patients who had Received at Least one Glenohumeral Intraarticular Corticosteroid Injections.

Variables	B	Wald	Significance	Exp (B)	95% Confidence interval for Exp (B)
Sex (1)†	−0.869	0.353	0.014*	0.419	0.210 to 0.837
Age	−0.058	8.638	0.003*	0.943	0.970 to 0.981
Arthritis grading‡		22.157	<0.001*		
Arthritis grading (1)	−2.054	21.769	<0.001*	0.128	0.054 to 0.304
Arthritis grading (2)	−0.418	1.069	0.301	0.658	0.298 to 1.454
Dominant Side (1)§	−0.393	1.452	0.228	0.675	0.356 to 1.279
Injection number	−0.124	1.538	0.215	0.884	0.727 to 1.074
Occupation¶		4.485	0.344		
Occupation (1)	1.531	2.206	0.138	4.623	0.613 to 34.872
Occupation (2)	1.585	2.416	0.120	4.878	0.661 to 35.975
Occupation (3)	0.841	0.707	0.401	2.320	0.326 to 16.498
Occupation (4)	1.650	2.686	1.101	5.207	0.724 to 37.458
Smoking#		6.304	0.043*		
Smoking (1)	−1.516	6.300	0.012*	0.220	0.067 to 0.717
Smoking (2)	−0.214	0.353	0.552	0.808	0.399 to 1.634
BMI	0.007	0.029	0.866	1.007	0.931 to 1.089
Obesity¥		2.396	0.302		
Obesity (1)	0.752	0.592	0.442	2.120	0.312– 14.392
Obesity (2)	0.924	1.804	0.179	2.519	0.654 to 9.697

Note: Regression model $R^2 = 0.204$ (Cox & Snell), 0.275 (Nagelkerke). Model $X^2 = 47.745$. $p < 0.001$.

*$p < 0.05$.

†Sex: Compared to females (categorical code 0), males (categorical code 1) have significantly lower odds of undergoing arthroplasty: Odd ratio = 0.419.

‡Arthritis grading: Compared to grade 3, grade 1 has significantly lower odds of undergoing arthroplasty: Odd ratio = 0.128. Compared to grade 3, grade 2 has no significantly different likelihood of undergoing arthroplasty.

§Dominant side: No significant difference between dominant side involvement (categorical code 1) and non-dominant side involvement (categorical code 0).

¶Occupation: No significant difference between retired (categorical code 0), sedentary (code 1), disabled (code 2), manual labor (code 3), and unemployed (code 4).

#Smoking: Compared to patients who never smoked (categorical code 0), current smokers (code 1) have significantly lower odds of undergoing arthroplasty: Odd ratio = 0.220. Compared to never smoked, former smokers (code 2) have no significantly different likelihood.

¥Obesity: No significant difference between morbidly obese (categorical code 0), normal (code 1), and obese (code 2).

injections. Lai *et al.*[6] found that the severity of hip joint space narrowing based on radiographs (Tönnis grade) was a significant predictor of undergoing hip arthroplasty. The exact reason why patients with more severe radiographic arthritic changes were more likely to undergo shoulder arthroplasty is unclear. Although the decision-making process must have been multifactorial, it can be speculated that patients with more severe arthritic changes were experiencing more severe and persistent pain despite corticosteroid injections, which ultimately might have led to a decision to receive arthroplasty. However, this notion cannot be verified with our current data because our study did not collect data of pain severity or response to injection. It is also possible that severe arthritic changes observed in radiographs might have influenced the perception of patients and surgeons about severity of arthritis toward recommending arthroplasty.

Our study also found that female patients were 2.4 times more likely to decide to undergo arthroplasty than male patients. This finding is in agreement with previously published studies that showed higher utilization of shoulder arthroplasty in female patients than male patients.[8,9] A retrospective study by Schoch *et al.* investigated the tipping point for undergoing shoulder arthroplasty in 5670 primary shoulder arthroplasty patients and found that female gender was significantly associated with a lower tipping point.[10] The reason for this difference is unclear, but one possible explanation is that women might have had increased baseline pain compared to men. Our study did not collect pain data and cannot provide evidence to support this speculation, but there are published studies showing that this gender difference might result from discrepancies in the ability to cope with pain, and women having greater expression and sensitivity to pain than men in severe diseases.[11,12] We performed an additional statistical analysis to see if there was any significant difference in arthritis grading between males and females, and found no significant difference ($p = 0.861$, X^2 test).

The present study found that younger age was a significant predictor of undergoing shoulder arthroplasty. Age has not been found to be an important predictor of undergoing arthroplasty in other orthopaedic literature. Our finding suggests that younger patients choose more definitive treatment – shoulder arthroplasty – than older patients potentially because pain and limitation from OA are less tolerable to younger patients. In our study, BMI was not found to be a

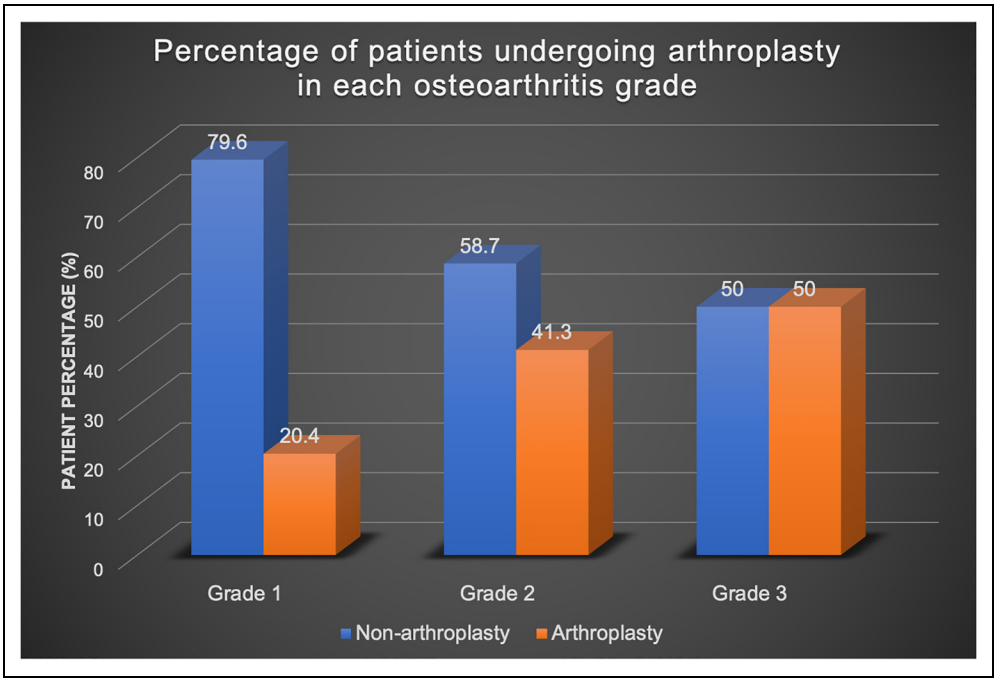

Figure 2. Radiographic severity of osteoarthritis at the time of injection was found to be a significant predictor of undergoing arthroplasty in future. Fifty percent of the shoulders with grade-3 arthritis received arthroplasty, whereas 20% of those with grade-1% and 41% of those with grade-2 arthritis received arthroplasty.

significant factor. This finding is different from the study by Schoch et al., which showed that a higher BMI was associated with a lower tipping point of undergoing anatomic shoulder arthroplasty in glenohumeral OA patients.[10]

In our study, 55% of the patients who had received an intraarticular glenohumeral injection ultimately chose not to undergo any surgical treatment. Approximately 22% of the patients chose to receive more injections only, and 33% chose not to receive any further treatment. Multiple factors must have played in the decision-making process, but it is noteworthy that more than 50% of patients ended up not having any surgery within 3 to 8 years of injection for one reason or another.

The present study has several important limitations to note. First, as a retrospective study, this study has weaknesses and biases that are typical of such studies. No standardized indications were used for intraarticular corticosteroid injection or shoulder arthroplasty. Rather, the decision was left up to the discussion between the physician and patient. This lack of standardized indications might have introduced biases and might have affected the result. Second, although the Samilson and Prieto classification system is known to have high intra- and inter-observer reliability,[13–15] it has not been validated in our institution. A single blinded observer rated all the radiographs, which might have introduced bias. Third, this study did not collect data on shoulder function or pain levels before or following injection. Therefore, the potential influence of pain level and efficacy of injection on treatment decision-making could not be investigated. Fourth, although done by experienced physicians, some of the injections were done without imaging guidance, and it is unknown how many of these injections were accurately done into the glenohumeral joint. Fifth, our results are based on a retrospective analysis of a database from a single institution at the Midwest region of the U.S. and may not be generalized to other types of practice or geographical regions. Lastly, our follow-up period was relatively short (ie, 3 to 8 years), and a longer follow-up might have resulted in different findings potentially with a higher percentage of patient going on to arthroplasty. Nonetheless, to our best knowledge, our study is the first to look at the clinical course of patients following an intraarticular corticosteroid injection for glenohumeral OA, and the study finding may be useful in counseling patients about their future clinical course when a corticosteroid injection is being contemplated as initial treatment .

In summary, approximately one third of patients who had undergone an intraarticular corticosteroid injection for glenohumeral OA eventually underwent shoulder arthroplasty within 3 to 8 years of injection. The severity of arthritic changes in radiographs, female gender, and younger age were significant predictors of undergoing shoulder arthroplasty. It was noted that 55% of patients did not receive any surgical treatment.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Informed Consent

Not applicable, because this article does not contain any studies with human or animal subjects.

ORCID iDs

H. Mike Kim https://orcid.org/0000-0002-5286-5335
Sally D. Heil https://orcid.org/0000-0001-9877-3017
Matthew J. Smith https://orcid.org/0000-0001-7187-2891

Trial Registration

Not applicable, because this article does not contain any clinical trials.

References

1. Matsen FA, Rockwood CA, Writh MA, et al. Glenohumeral arthritis and its management. In: *The Shoulder. 3rd ed*. Saunders; 2004:879–1009.
2. Millett PJ, Fritz EM, Frangiamore SJ, et al. Arthroscopic management of glenohumeral arthritis: a joint preservation approach. *J Am Acad Orthop Surg*. 2018;26(21):745–752.
3. Izquierdo R, Voloshin I, Edwards S, et al. Treatment of glenohumeral osteoarthritis. *J Am Acad Orthop Surg*. 2010;18(6):375–382.
4. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383.
5. Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. *J Bone Joint Surg Am*. 1983;65(4):456–460.
6. Lai WC, Arshi A, Wang D, et al. Efficacy of intraarticular corticosteroid hip injections for osteoarthritis and subsequent surgery. *Skeletal Radiol*. 2018;47(12):1635–1640.
7. Reidy M, Cousins G, Finlayson D. Corticosteroid injection of the arthritic hip: what is the indication? *Scott Med J*. 2015;60(1):29–31.
8. Eichinger JK, Greenhouse AR, Rao MV, et al. Racial and sex disparities in utilization rates for shoulder arthroplasty in the United States disparities in shoulder arthroplasty. *J Orthop*. 2019;16(3):195–200.
9. Yu S, Mahure SA, Branch N, et al. Impact of race and gender on utilization rate of total shoulder arthroplasty. *Orthopedics*. 2016;39(3):e538–e544.
10. Schoch BS, King JJ, Wright TW, et al. Defining the tipping point for primary shoulder arthroplasty. *JSES Open Access*. 2019;3(4):273–277.
11. Keefe FJ, Affleck G, France CR, et al. Gender differences in pain, coping, and mood in individuals having osteoarthritic knee pain: a within-day analysis. *Pain*. 2004;110(3):571–577.
12. Keefe FJ, Lefebvre JC, Egert JR, et al. The relationship of gender to pain, pain behavior, and disability in osteoarthritis patients: the role of catastrophizing. *Pain*. 2000;87(3):325–334.
13. Brox JI, Lereim P, Merckoll E, et al. Radiographic classification of glenohumeral arthrosis. *Acta Orthop Scand*. 2003;74(2):186–189.
14. Elsharkawi M, Cakir B, Reichel H, et al. Reliability of radiologic glenohumeral osteoarthritis classifications. *J Shoulder Elbow Surg*. 2013;22(8):1063–1067.
15. Ilg A, Bankes MJ, Emery RJ. The intra- and inter-observer reliability of the samilson and prieto grading system of glenohumeral arthropathy. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(3):187–190.

H. Mike Kim, MD, is a shoulder and elbow surgeon at University of Missouri in Columbia. His research is focused on biomechanics of shoulder arthroplasty, pathogenesis of rotator cuff tear, and shoulder periprosthetic infection. He is currently investigating postoperative pain control methods following shoulder procedures.

Maaz Muhammad is a third-year medical student at University of Missouri School of Medicine and is interested in pursuing an orthopaedic surgery career.

Sally D. Heil is a first-year medical student at University of Missiour School of Medicine and is an eilte runner who is keen on medical research.

Matthew Smith, MD, is a shoulder and elbow surgeon at University of Missouri in Columbia. He has keen interest in engineering aspects of shoulder arthroplasty and has participated in designing several shoulder prostheses.