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Open versus arthroscopic elbow arthrolysis for primary osteoarthritis: A comparison of demographics and complications at two years☆

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ABSTRACT

Introduction: Open techniques have traditionally been utilized in the surgical management of elbow osteoarthritis (OA). However, advances in elbow arthroscopy, in conjunction with the movement towards minimally invasive surgery, have led to an increase in the utilization of an arthroscopic approach. The primary aim of this investigation was to compare demographics and complication rates between patients undergoing open or arthroscopic arthrolysis for elbow OA with a secondary objective of identifying risk factors for infection with each treatment.
Methods: A retrospective review of a private, all-payer database was performed to identify patients undergoing either open (n = 1482) or arthroscopic (n = 2341) arthrolysis for elbow osteoarthritis. The primary outcome was 2-year complications, which included infection, wound complications, and nerve injuries. Categorical variables were compared utilizing chi-square analyses, while continuous variables were compared using independent sample t-tests. Odd ratios (OR) were ascertained to quantify the risk attributed to open arthrolysis compared to arthroscopic. Multivariable logistic regression was performed to assess risk factors for infection following open or arthroscopic arthrolysis of an elbow with OA.
Results: Age was significantly higher in the open cohort (55 ± 13.4 years) compared to the arthroscopic cohort (52 ± 13.1 years) ($p < 0.001$). The open cohort was more likely to be female (32.0 vs. 22.9%, $p < 0.001$) and have a Charlson Comorbidity Index (CCI) greater than three (9.2 vs. 7.1%, $p < 0.001$). Open procedures were associated with an increased risk of nerve injury (OR: 1.50) and wound complications (OR: 7.70) compared to arthroscopic arthrolysis. Multivariable logistic regression identified open procedures as a risk factor for infection (OR: 11.15). Moreover, diabetes (OR: 1.48), chronic kidney disease (OR: 1.89) and tobacco use (OR: 2.29) were found as risk factors for infection among the open cohort.
Conclusions: This study found patients undergoing open arthrolysis of OA to be older and have a greater number of medical comorbidities compared to those undergoing arthroscopic arthrolysis. Open arthrolysis was associated with an increased rate of infection, nerve injury and wound complications compared to arthroscopic arthrolysis. After controlling for age and comorbidities with multivariable logistic regression, open arthrolysis remained a risk factor for infection. Arthroscopic elbow arthrolysis is associated with a lower risk of complications, including infection and may be favored for the management of OA of the elbow.
Level of Evidence: III (retrospective cohort study).

1. Introduction

Primary elbow osteoarthritis (OA) is a relatively uncommon disorder, found in approximately 2–3% of the population,[1] but can be disabling to those affected. The condition demonstrates a disproportionate predilection for the dominant extremity in male athletes and laborers.[2,3] Symptomatic elbow OA commonly manifests as increased pain, locking, restriction of range of motion, and sometimes, neuropathic ulnar nerve symptoms.[4,5] Elbow OA is often amenable to non-operative treatment, which may be attributed to the elbow joint's relative non-weight-bearing status and the ability to maintain daily function despite a restricted range of motion.[6–9] In some instances,

☆ Institutional review board approval was not required for this study as the data were retrieved from a de-identified database.

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however, surgical intervention may be indicated to ameliorate refractory and disabling symptoms experienced from elbow OA.

Historically, an open approach with capsular release, removal of osteophytes, and loose bodies has been the preferred surgical technique for management of elbow OA, however elbow arthroscopy has become an increasingly utilized treatment modality with good results reported in the literature.[10,11] Recent systematic reviews and meta-analyses have been performed comparing arthroscopic versus open management of elbow osteoarthritis, touting increased complication rates associated with open procedures.[10,12] Due to the infrequency of these procedures, the number of examined patients in these reviews was relatively low and commonly included all forms of osteoarthritis, including primary osteoarthritis, rheumatoid arthritis, and post-traumatic arthritis.

The primary aim of the present study was to utilize a large database to compare demographics and complications between those undergoing open or arthroscopic arthrolysis for the management of primary elbow OA. The secondary aim was to identify independent risk factors for infection within each surgical treatment. Based on the existing literature, our hypothesis was that arthroscopic arthrolysis would have a reduced rate of complications compared to open arthrolysis.

2. Methods

2.1. Data source

A retrospective review of a private, all-payer database (PearlDiver Technologies, Colorado Springs, CO, USA) was performed, which included patients from 2010 to Q3 of 2020. The query was initially formulated to identify all patients undergoing either open (n = 16,975) or arthroscopic (n = 12,965) arthrolysis procedures utilizing their respective current procedural technology (CPT) codes (Appendix A). These patients were subsequently stratified based on their International Classification of Diseases, Ninth (ICD-9) or Tenth Edition (ICD-10) coding, which resulted in 1482 patients for open arthrolysis, and 2341 patients for arthroscopic arthrolysis for primary elbow osteoarthritis. Inclusion criteria were as follows: any patient aged >18 years, appropriate CPT/ICD-9/ICD-10 coding and minimum two-year follow-up. Patients were excluded if they underwent an elbow arthrolysis procedure for any indication other than primary osteoarthritis. Identification of patients with appropriate follow-up was achieved through the "ACTIVE" function within the PearlDiver supercomputer. The utilized database contains solely deidentified patient information and is Health Insurance Portability and Accountability Act (HIPAA) compliant, and as such, was found to be exempt from local institutional review board approval.

2.2. Analyzed variables

Demographics examined included age, sex and Charlson Comorbidity Index (CCI); various specific comorbidities were assessed including alcohol abuse, chronic kidney disease (CKD), diabetes mellitus (DM), and obesity. The CCI is an assessment tool purposed to predict one-year mortality, based on the presence, or lack thereof, of 19 medical conditions, and is commonly utilized as a surrogate for health status.[13] Patients with specific comorbidities were identified by using the respective ICD-9 or -10 codes. Infection, wound complications, and nerve injuries were the primary complications examined at two years post-operatively. Post-operative complications were identified utilizing their respective ICD-9 and -10 codes and querying PearlDiver utilizing the "AND" function.

2.3. Data analysis

Categorical variables between arthroscopic and open groups were compared utilizing chi-square analyses, while continuous variables within these respective groups were compared using independent sample t-tests. Odd ratios (OR) were included to quantify the risk attributed to open procedures when compared to arthroscopic arthrolysis. Thereafter, multivariable logistic regression was performed to adjust for baseline characteristics and to assess for associated risk factors for infection following open or arthroscopic arthrolysis of an elbow with OA. Utilizing the multivariate regression model, patients with a comorbidity were compared to patients with the same comorbidity and procedure of interest. The threshold for statistical significance was set to a p value of less than 0.05 for all parameters. All analyzed data was obtained through R software (University of Auckland, Auckland, New Zealand) embedded within the PearlDiver supercomputer software.

3. Results

3.1. Demographics

All demographics among the groups were found to be significantly different, except for alcohol and tobacco use (Table 1). Age was statistically higher in open elbow arthrolysis patients (open OA: 55 ± 13.4 vs. arthroscopic OA: 52 ± 13.1 years, $p < 0.001$). A larger proportion of females underwent open procedures (32.0%) compared to arthroscopic procedures (22.9%) ($p < 0.001$). A larger proportion of patients with CCI >3 underwent open procedures (9.2 vs. 7.1%, $p < 0.001$). Patients undergoing open arthrolysis were more likely to have CKD (15.5 vs. 8.8%, $p < 0.001$), DM (36.2 vs. 26.5%, $p < 0.001$), and obesity (44.2 vs. 38.0%, $p < 0.001$). More open arthrolysis patients underwent ulnar nerve transposition than closed (23.8 vs. 15.8%, $p < 0.001$).

3.2. Two-year outcomes

Open elbow arthrolysis was associated with significantly higher rates of all examined complications at two-years postoperatively (Table 2). Specifically, open procedures demonstrated higher rates of deep infections (9.9 vs. 1.0%, $p < 0.001$), wound complications (9.9 vs. 1.4%, $p < 0.001$), and nerve injury (20.1 vs. 14.4%, $p = 0.04$). Open elbow arthrolysis was associated with an increased risk of infection (OR: 5.96, 95% CI: 4.00–8.87), nerve injury (OR: 2.55, 95% CI: 1.10–5.91) and wound complications (OR: 5.60, 95% CI: 3.63–8.65) compared to arthroscopic arthrolysis (Table 3).

After adjusting for baseline characteristics such as, age, sex, alcohol abuse, CKD, DM, obesity, and tobacco use, open elbow arthrolysis demonstrated an OR of 11.15 (95% CI: 9.32–13.46) for infection compared to arthroscopic elbow arthrolysis. Female gender OR: 1.25; 95% CI: 1.09–1.43), alcohol use (OR: 1.31; 95% CI: 1.10–1.56), CKD (OR: 1.89, 95% CI: 1.63–2.20), DM (OR: 1.48; 95% CI: 1.30–1.69), and

Table 1
Demographics and baseline characteristics.

	Open Elbow Arthrolysis (n = 1482)	Arthroscopic Elbow Arthrolysis (n = 2341)	*p*-value
Age (SD)	55 (13.4)	52 (13.1)	<0.001
Sex			<0.001
Female	474 (32.0)	536 (22.9)	
Male	1008 (68.0)	1805 (77.1)	
Alcohol Abuse	188 (12.7)	192 (8.2)	<0.001
CCI > 3	215 (9.2)	167 (7.1)	<0.001
Chronic Kidney Disease	230 (15.5)	207 (8.8)	<0.001
DM	536 (36.2)	621 (26.5)	<0.001
Obesity	655 (44.2)	890 (38.0)	<0.001
Tobacco Use	667 (45.0)	919 (39.3)	<0.001
Same Day Transposition	353 (23.8)	370 (15.8)	<0.001
In situ decompression	24 (1.6)	[a]([a])	<0.001

SD: standard deviation; DM: diabetes mellitus; CCI: Charlson Comorbidity Index.
[a] Numeric values < 11 must be censored in accordance with the PearlDiver database confidentiality agreement.

Table 2
Bivariate analysis of post-operative outcomes.

	Open Elbow Arthrolysis(n = 1482)	Arthroscopic Elbow Arthrolysis (n = 2341)	*p*-value
Complications			
Deep Infection	181 (9.9)	29 (1.0)	<0.001
Nerve Injury	298 (20.1)	337 (14.4)	<0.001
Wound Complications	147 (9.9)	33 (1.4)	<0.001

Table 3
Odds Ratios of Complications: Open Elbow Arthrolysis vs. Arthroscopic.

	Open Elbow Arthrolysis	
	OR	95% CI
In Situ Decompression	3.84	1.83–8.05
Complications		
Deep Infection	11.09	7.45–16.51
Nerve Injury	1.50	1.26–1.78
Wound Complications	7.70	5.25–11.30

*Referent group: Patients who underwent arthroscopic elbow arthrolysis.
OR: odds ratio; 95% CI: 95% confidence intervals.

tobacco use (OR: 2.29, 95% CI: 2.00–2.63) as associated risks for infection among the open elbow arthrolysis cohort (Table 4). Age less than 60 years (OR: 0.53; 95% CI: 0.42–0.68) was found to be protective for infection, while obesity was not found to be a risk factor (OR: 0.90; 95% CI: 0.79–1.03).

4. Discussion

This study utilized a large database to compare the demographics and two-year post-operative complications between those undergoing open or arthroscopic elbow arthrolysis procedures for the management of osteoarthritis. Open procedures were more commonly performed in patients with higher comorbidity profiles, and the procedure demonstrated higher rates of all analyzed complications at two years. After adjusting baseline characteristics, open elbow arthrolysis demonstrated a significantly higher risk for infection compared to arthroscopic arthrolysis.

The present study found open arthrolysis to be associated with a greater risk of the three primary outcomes: infection, nerve injury, and wound complications, which expands on previous reports in the literature. White et al.[10] performed a systematic review of 42 studies comparing open to arthroscopic elbow arthrolysis for the management of elbow OA and reported that open procedures demonstrate higher rates of deep infection (0.0% in arthroscopic, 0.73% in open). However, neurologic complications, the most common complication observed, were seen at similar rates between the procedures (2.18% in arthroscopic, 1.9% in open procedures). Additionally, the rate of hematoma formation was found to be similar between groups (1.21% in arthroscopic and 0.88% in open). De Klerk et al.[12] performed a systematic review and meta-analysis of 21 studies comparing open and arthroscopic arthrolysis in primary elbow OA patients and found higher rates of complications in open procedures. Similar to the present study, open arthrolysis conferred higher rates of neurologic (8% open, 2% arthroscopic) and wound complications (hematoma formation, 1% vs. 0%), but found infection rates to be identical (1%). The present study employed a large database to gather thousands of patients for analysis and is powered to provide unique insight on the comparison between open and arthroscopic elbow procedures.

Table 4
Independent variables for infection.

Female	1.25	1.09–1.43	0.001
Age <60 years	0.53	0.42–0.68	<0.001
Alcohol Abuse	1.31	1.10–1.56	0.002
Chronic Kidney Disease	1.89	1.63–2.20	<0.001
Diabetes Mellitus	1.48	1.30–1.69	<0.001
Obesity	0.90	0.79–1.03	0.138
Tobacco Use	2.29	2.00–2.63	<0.001
Open Elbow Arthrolysis	11.15	9.32–13.46	<0.001

*Referent group: Patients who underwent arthroscopic elbow arthrolysis.
OR: odds ratio; 95% CI: 95% confidence intervals.

The current study found open procedures to have a higher overall risk for infection. Tobacco use presented the highest additional risk for those undergoing an open procedure. Another important finding of the present study is that DM was associated with an increased risk of infection following open arthrolysis procedures compared to arthroscopic. This may be related to the larger incisions utilized in an open approach and the poor wound healing ability known to accompany DM.[14] To our knowledge, no study has previously performed a subgroup analysis to compare the infection risk profiles of specific comorbidities in those undergoing open or arthroscopic elbow arthrolysis. However, Camp et al.[15] performed a retrospective database review of patients undergoing elbow arthroscopy (for any reason), and similarly found alcohol use, tobacco use, and DM as risk factors for infection. The present study adds to the literature by identifying patients most at-risk for infection following their respective procedures.

This study is not without limitations. First and foremost, the findings presented herein are derived from a database, and its validity is highly dependent upon accurate data entry. However, the entity in possession of the database routinely performs audits to ensure the data is appropriately entered and represented. Additionally, the study was performed in a retrospective manner and the cohorts obtained for this study is predicated on the appropriate selection of ICD-9, and ICD-10 coding. Range of motion could not be assessed due to the nature of the database. Nonetheless, multiple authors reviewed these queries to ensure its appropriateness in data collection to obtain the most representative cohorts. Lastly, conclusions obtained from this study may be a representation of correlation and not causation. These potential associations were mitigated by performing regression analyses, isolating for specific risk factors. The study presented made every attempt to avoid the potential downfalls associated with database studies to provide bona fide conclusions regarding open or arthroscopic procedures for the management of elbow OA.

5. Conclusion

Our study found patients undergoing open arthrolysis for primary OA to be older patients with more medical comorbidities compared to those undergoing arthroscopic arthrolysis. Open procedures were associated with significantly increased rates of infection, nerve injury and wound complications compared to arthroscopic arthrolysis. After controlling for age and comorbidities with multivariable logistic regression, open arthrolysis remained a risk factor for infection, while tobacco use was the greatest risk factor for infection. Overall, arthroscopic elbow arthrolysis appears to confer a lower risk for complications and may be the preferred method for the management of OA of the elbow.

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Declaration of competing interest

The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Appendix A. CPT codes used for query

Open Arthrolysis	CPT-24006, CPT-24140, CPT-24145, CPT-24147, CPT-24149, ICD-10-P-0RBM0ZZ, ICD-10-P-0RBL0ZZ, ICD-10-P-0RNL0ZZ, ICD-10-P-0RNM0ZZ, ICD-10-P-0RNLXZZ, ICD-10-P-0RNMXZZ
Arthroscopic Arthrolysis	CPT-29837, CPT-29838, CPT-29835, CPT-29836, ICD-10-P-0RNM4ZZ, ICD-10-P-0RNL4ZZ, ICD-10-P-0RBM4ZZ, ICD-10-P-0RBL4ZZ

References

1 Stanley D. Prevalence and etiology of symptomatic elbow osteoarthritis. *J Shoulder Elbow Surg*. 1994;3(6):386–389. https://doi.org/10.1016/S1058-2746(09)80024-4.

2 Morrey BF. Primary degenerative arthritis of the elbow. Treatment by ulnohumeral arthroplasty. *J Bone Joint Surg Br*. 1992;74(3):409–413. https://doi.org/10.1302/0301-620X.74B3.1587890.

3 Papatheodorou LK, Baratz ME, Sotereanos DG. Elbow arthritis: current concepts. *J Hand Surg Am*. 2013;38(3):605–613. https://doi.org/10.1016/J.JHSA.2012.12.037.

4 Ravalli S, Pulici C, Binetti S, Aglieco A, Vecchio M, Musumeci G. An overview of the pathogenesis and treatment of elbow osteoarthritis. *J Funct Morphol Kinesiol*. 2019;4(2). https://doi.org/10.3390/jfmk4020030.

5 Kim H, Kholinne E, Kwak JM. Ulnar nerve decompression with osteocapsular arthroplasty for primary elbow osteoarthritis. J Orthop Surg. 30(2): 10225536221109914. doi:10.1177/10225536221109914.

6 Vasen AP, Lacey SH, Keith MW, Shaffer JW. Functional range of motion of the elbow. *J Hand Surg Am*. 1995;20(2):288–292. https://doi.org/10.1016/S0363-5023(05)80028-0.

7 Sardelli M, Tashjian RZ, MacWilliams BA. Functional elbow range of motion for contemporary tasks. *J Bone Joint Surg Am*. 2011;93(5):471–477. https://doi.org/10.2106/JBJS.I.01633.

8 Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal functional elbow motion. *J Bone Joint Surg Am*. 1981;63(6):872–877.

9 Haverstock JP, King GJW, Athwal GS, Johnson JA, Langohr GDG. Elbow motion patterns during daily activity. *J Shoulder Elbow Surg*. 2020;29(10):2007–2014. https://doi.org/10.1016/j.jse.2020.03.015.

10 White CHR, Ravi V, Watson J, Badhrinarayanan S, Phadnis J. A systematic review of arthroscopic versus open debridement of the arthritic elbow. *Arthroscopy*. 2021;37(2):747–758. https://doi.org/10.1016/J.ARTHRO.2020.09.005. e1.

11 Sochacki KR, Jack RA, Hirase T, et al. Arthroscopic debridement for primary degenerative osteoarthritis of the elbow leads to significant improvement in range of motion and clinical outcomes: a systematic review. *Arthroscopy*. 2017;33(12):2255–2262. https://doi.org/10.1016/J.ARTHRO.2017.08.247.

12 de Klerk HH, Welsink CL, Spaans AJ, Verweij LPE, van den Bekerom MPJ. Arthroscopic and open debridement in primary elbow osteoarthritis: a systematic review and meta-analysis. *EFORT Open Rev*. 2020;5(12):875–882. https://doi.org/10.1302/2058-5241.5.190095.

13 Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson comorbidity Index: a critical review of clinimetric properties. *Psychother Psychosom*. 2022;91(1):8–35. https://doi.org/10.1159/000521288.

14 Greenhalgh DG. Wound healing and diabetes mellitus. *Clin Plast Surg*. 2003;30(1):37–45. https://doi.org/10.1016/s0094-1298(02)00066-4.

15 Camp CL, Cancienne JM, Degen RM, Dines JS, Altchek DW, Werner BC. Factors that increase the risk of infection after elbow arthroscopy: analysis of patient demographics, medical comorbidities, and steroid injections in 2,704 medicare patients. *Arthrosc J Arthrosc Relat Surg*. 2017;33(6):1175–1179. https://doi.org/10.1016/j.arthro.2017.02.004.