Arthroscopic distal clavicle excision is associated with fewer postoperative complications than open

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Background: The rate of complications of open compared to arthroscopic distal clavicle excision remain poorly studied. Therefore, the purpose of this investigation was to (1) Identify most recent national trends in the usage of open vs. arthroscopic approaches for distal clavicle excision (DCE) from 2007 to 2017; (2) to identify and compare the complication rates for both approaches, and to identify patient-specific risk factors for complications; (3) to identify and compare the revision rate for both approaches; and (4) to identify and compare the reimbursement of each approach.

Methods: The PearlDiver database was reviewed for patients undergoing DCE from 2007 to 2017. Patients were stratified into 2 cohorts: those undergoing arthroscopic DCE (n = 8933) and those undergoing open DCE (n = 2295). The rate of postoperative complications within 90 days was calculated and compared. The revision rate and reimbursement of the arthroscopic and open approach were compared. Statistical analysis included chi-square testing to compare the rates of postoperative complications and multivariate logistic regression analysis to identify risk factors for complications within 90 days. Results were considered significant at P < .05.

Results: The percentage of DCEs performed arthroscopically has significantly increased from 53.9% in 2007 to 69.8% in 2016, with a concomitant decrease in the use of open DCE from 46.1% in 2007 to 30.2% in 2016. The open approach was associated with significantly more postoperative complications, including a significantly greater incidence of surgical site infection (1.9% vs. 0.3%; P < .001), wound disruption (0.3% vs. 0.1%; P < .001), hematoma (0.9% vs. 0.2%; P < .001), and transfusion (0.6% vs. 0.1%; P < .001), than arthroscopic DCE. Several risk factors, including open approach, diabetes, heart disease, tobacco use, chronic kidney disease, and female gender, were identified as independent risk factors for complications after DCE. There was no significant difference in revision rate between open and arthroscopic approaches (P = .126). The reimbursement of open and arthroscopic DCE procedures were comparable, with median reimbursements of $5408 and $5,447, respectively (P = .853).

Conclusion: Both arthroscopic and open DCE techniques were found to have similar reimbursement amounts, with a low rate of complications, although the open technique had a higher rate of early complications such as surgical site infection. Over the study period, there was an increase in the utilization of arthroscopic DCE, while the incidence of the open technique remained constant.

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The open approach allows for direct visualization of the joint space. However, it risks injury to the superior capsular and ligamentous structures and has been associated with an increased incidence of AC joint instability and postoperative shoulder weakness.\(^1,2,3,11,22\) The open approach may be preferred in revision cases or cases of isolated distal clavicle osteolysis or arthritis in which visualization of the glenohumeral joint or subacromial space is unnecessary.\(^1\) However, impingement lesions as well as other glenohumeral lesions are often difficult to appreciate on preoperative imaging, and the arthroscopic technique confers the advantage of being able to diagnose and treat these lesions.\(^15\)

The arthroscopic approach is associated with less tissue destruction, improved cosmesis,\(^1,4,8\) as well as less postoperative pain, faster return to activities of daily living,\(^1,15\) and higher patient satisfaction than the open approach.\(^1,5,10,14,15\) Cadaveric evidence has demonstrated the technical adequacy of the arthroscopic approach.\(^1,5\) However, the limited visualization inherent to arthroscopic surgery has sparked concerns over the ability to perform a complete excision of the distal clavicle, especially of the superior-posterior aspect, and consequently result in persistent pain and dysfunction necessitating revision surgery.\(^24\)

Previous investigations which studied demographics and trends of patients undergoing arthroscopic vs. open DCE have found that arthroscopic DCEs progressively increased, and open DCEs decreased from 2004 to 2013.\(^1,13\) However, recent data on trends in the usage of these two techniques are lacking. In addition, little evidence comparing the reimbursement and incidence of postoperative complications between arthroscopic and open techniques is available. Therefore, the objectives of this study were to (1) identify most recent national trends in the usage of open vs. arthroscopic approaches for DCE from 2007 to 2017; (2) to identify and compare the complication rates for both approaches, and to identify patient-specific risk factors for complications; (3) to identify and compare the revision rate for both approaches; and (4) to identify and compare the average reimbursement rates of each approach.

**Methods**

**Database**

In this study, the Humana administrative claims database was queried using the PearlDiver Patient Record Database (PearlDiver Inc, Fort Wayne, IN; www.pearldiverinc.com). The database houses deidentified patient information from a variety of insurers including Humana’s claims database and the Medicare Standard Analytical files from 2007 to 2017. Data regarding patient demographics, medical comorbidities, postoperative complications, prescription medication usage, geographic information, and procedural volumes were queried using International Classification of Disease Ninth and Tenth Revision (ICD-9 and ICD-10) codes, Current Procedural Terminology (CPT) codes, and National Drug Codes. For this study, the Humana Orthopedic private payer database was used. The advantages of this database include a large national patient population (up to 11 million patients per year), ability to analyze various comorbidities and rare postoperative complications, and the ability to longitudinally track patients. This study was granted exemption from the institutional review board as PearlDiver uses deidentified patient information.

**Patient selection and study outcomes**

A retrospective analysis of patients undergoing DCE was performed from 2007 to 2017. All patients who underwent open and arthroscopic DCE were identified using the CPT codes 23120 and 29824, respectively. Patients of all ages were included. Patients who were not active for at least 90 days after DCE were not included in the study. A total of 11,228 patients were identified using the aforementioned inclusion criteria. Of these patients, 8933 patients (79.5%) underwent arthroscopic DCE, with the remainder undergoing open DCE. To assess trends in the amount of DCE being performed each year, incidence of both open and arthroscopic DCE was plotted in Fig. 1 against time. The annual incidence of arthroscopic DCE increased from 2007 to 2016. Over the same time...
period, the incidence of open DCE remained stable, whereas the percentage of DCEs performed via an open technique decreased significantly over this time period (46.1% in 2007 vs. 30.2% in 2016, \( P < .001 \)) (Fig. 1A and B). The percentage of DCEs being performed arthroscopically increased over the study period (53.9% in 2007 vs. 69.8% in 2016, \( P < .001 \)). Notably, the ratio of arthroscopic DCE to open DCE decreased across all age groups, and by age 80, patients are equally likely to undergo arthroscopic DCE as open (Fig. 2). Patient demographics for the open and arthroscopic cohorts can be found in Table I.

Open DCE was associated with a significantly greater incidence of postoperative complications (10.8% vs. 7.3%, \( P < .001 \)) relative to arthroscopic DCE (Table II). Specifically, open DCE was associated with a significantly greater incidence of wound disruption (0.3% vs. 0.1%, \( P < .001 \)), postoperative hematoma (0.9% vs. 0.2%, \( P = .001 \)), transfusion (0.6% vs. 0.1%, \( P < .001 \)), andSSI (1.9% vs. 0.3%, \( P < .001 \)) than arthroscopic DCE (Table II).

Multivariate regression identified female gender (\( OR = 1.61; 95\% CI, 1.44-1.80; P < .001 \)), congestive heart failure (\( OR = 1.36; 95\% CI, 1.14-1.63; P < .001 \)), chronic obstructive pulmonary disease (\( OR = 1.53; 95\% CI, 1.37-1.72; P < .001 \)), chronic kidney disease (\( OR = 1.88; 95\% CI, 1.63-2.17; P < .001 \)), diabetes (\( OR = 1.43; 95\% CI, 1.28-1.61; P < .001 \)), ischemic heart disease (\( OR = 1.27; 95\% CI, 1.22-1.45; P < .001 \)), pulmonary heart disease (\( OR = 3.26; 95\% CI, 2.80-3.80; P < .001 \)), and tobacco use (\( OR = 1.24; 95\% CI, 1.10-1.39; P < .001 \)) as risk factors for complications in patients undergoing DCE (Table III). Notably, open DCE was a significant risk factor for complications after DCE (\( OR = 1.73; 95\% CI, 1.11-2.69; P = .015 \)), whereas arthroscopic DCE was not (\( OR = 0.92; 95\% CI, 0.59-1.44; P = .718 \) ) (Table III).

Subgroup analysis identified female gender (\( OR = 1.76; 95\% CI, 1.30-2.38; P < .001 \)), congestive heart failure (\( OR = 1.91; 95\% CI, 1.32-2.73; P < .001 \)), diabetes (\( OR = 1.58; 95\% CI, 1.15-2.17; P = .005 \)), pulmonary heart disease (\( OR = 1.70; 95\% CI, 1.11-2.56; P = .012 \)), and tobacco use (\( OR = 1.42; 95\% CI, 1.04-1.91; P = .024 \)) as risk factors for complications in patients undergoing open DCE and female gender (\( OR = 1.83; 95\% CI, 1.53-2.18; P < .001 \)), chronic obstructive pulmonary disease (\( OR = 1.54; 95\% CI, 1.28-1.84; P < .001 \)), chronic kidney disease (\( OR = 1.79; 95\% CI, 1.46-2.19; P < .001 \)), ischemic heart disease (\( OR = 1.34; 95\% CI, 1.11-1.62; P = .002 \)), and pulmonary heart disease (\( OR = 2.37; 95\% CI, 1.85-3.01; P < .001 \)) as risk factors for complications in patients undergoing arthroscopic DCE (Table IV). Notably, concurrent SAD and BT were not noted to be significant risk factors for complications after open or arthroscopic DCE (Table IV).

There was no significant difference in the revision rate between patients undergoing arthroscopic and open DCE (1.3% vs. 0.7%; \( P = .126 \)) (Table V).

**Discussion**

The principle findings of this investigation are as follows: (1) The percentage of DCEs performed arthroscopically has significantly increased from 53.9% in 2007 to 69.8% in 2016, with a concomitant decrease in the use of open DCE from 46.1% in 2007 to 30.2% in 2016, a change that appears to be driven by an increase in the utilization of arthroscopic DCE, as the incidence of open DCE has remained stable; (2) the open approach was associated with significantly more postoperative complications than the arthroscopic approach, and several risk factors, including open approach, diabetes, heart disease, tobacco use, chronic kidney disease, and female gender, were identified as independent risk factors for complications after DCE; (3) there was no significant difference in revision rate between open and arthroscopic approaches; and finally, (4) there was no significant difference in the average reimbursement of either approach.

In a previous investigation, Alluri et al used a national database to study the trends in arthroscopic and open DCE from 2004 to 2009. The authors found that over this time period, the incidence of arthroscopic DCE increased significantly, whereas the incidence of open DCE significantly decreased. The results of our investigation demonstrated a similar increase in the incidence of arthroscopic DCE from 2007 to 2017. The observed increase in the utilization of arthroscopic DCE over the last two decades is likely multifactorial. The arthroscopic approach affords the unique benefit of being able to diagnose and treat shoulder pathology that may not have been evident on preoperative imaging, a luxury unavailable when DCE is performed via an open approach. Arthroscopic DCE is achieved in a minimally invasive fashion that avoids detaching the deltoid fascia or violating the superior or posterior AC ligaments, which may contribute to less postoperative AC joint instability or shoulder weakness relative to the open approach. Arthroscopic training in residency, fellowship, and various courses is continually improving, and surgeons early in practice are increasingly comfortable with arthroscopic management of AC pathology.
However, the results of this study demonstrate that open DCE is still being performed, albeit at less than half the overall rate of arthroscopic DCE. It is likely that several factors underpin this finding. First, the cohort of patients who underwent open DCE were significantly older than those who underwent arthroscopic DCE. Older patients often present with pathology that may be more effectively treated through an open approach, such as AC joint cysts, large superior osteophytes, and revision cases. On the other hand, younger patients who present with osteolysis may be more amenable to treatment through arthroscopic techniques. Another potential explanation is that these cases represent the practice of those surgeons who were trained to perform the procedure via an open approach.1 Further retrospective studies are necessary to confirm whether these trends are based on the offending diagnosis requiring DCE or surgeon preference.

Notably, Alluri et al found that arthroscopic DCE was more common in younger patients (50 to 59 years old) than open DCE, which was most common in patients aged 60 to 69 years.1 The
results of our study support this finding—the ratio of arthroscopic DCE to open DCE decreased across all age groups, and by age 80 years, patients are equally likely to undergo arthroscopic DCE as open. In addition, Alluri et al found that of patients undergoing DCE, SAD was performed with 23% of open DCE, whereas it was 95% with arthroscopic DCE.1 The present investigation examined the total reimbursement for the day of surgery within this database, and therefore, the impact of open vs. arthroscopic DCE may require an inpatient stay and longer employee disability.25

| Variable     | OR (95% CI) | P value |
|--------------|-------------|---------|
| Open DCE     | 1.73 (1.11-2.69) | .015*   |
| Arthroscopic DCE | 0.70 (1.09-1.31) | .479   |
| Female gender | 2.24 (1.07-4.68) | .032   |
| CHF          | 3.12 (1.46-6.64) | .003   |
| COPD         | 1.49 (0.96-2.32) | .072   |
| CKD          | 1.80 (1.18-2.73) | .005   |
| Diabetes     | 2.35 (1.37-4.02) | .002   |
| IHD          | 1.57 (1.05-2.34) | .032   |
| PHD          | 1.59 (1.12-2.24) | .005   |
| Tobacco use  | 1.42 (1.04-1.91) | .020   |
| Revision, n  | 861          | .126    |
| Arthroscopic DCE | 6             | .70     |
| Revision, n  | 1587         | 1.39    |

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; IHD, ischemic heart disease; PHD, pulmonary heart disease; *Diabetes, pulmonary heart disease; OR, odds ratio; CI, confidence interval.

*Indicates any value of P<.05.

Table V

Revision rates for patients who have a minimum of 5 y follow-up within the Humana database.

| Variable     | OR (95% CI) | P value |
|--------------|-------------|---------|
| Open DCE     | 1.73 (1.11-2.69) | .015*   |
| Arthroscopic DCE | 0.70 (1.09-1.31) | .479   |
| Female gender | 2.24 (1.07-4.68) | .032   |
| CHF          | 3.12 (1.46-6.64) | .003   |
| COPD         | 1.49 (0.96-2.32) | .072   |
| CKD          | 1.80 (1.18-2.73) | .005   |
| Diabetes     | 2.35 (1.37-4.02) | .002   |
| IHD          | 1.57 (1.05-2.34) | .032   |
| PHD          | 1.59 (1.12-2.24) | .005   |
| Tobacco use  | 1.42 (1.04-1.91) | .020   |
| Revision, n  | 861          | .126    |
| Arthroscopic DCE | 6             | .70     |
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CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; IHD, ischemic heart disease; PHD, pulmonary heart disease; *Diabetes, pulmonary heart disease; OR, odds ratio; CI, confidence interval.

*Indicates any value of P<.05.

Table IV

Subgroup analysis of open vs. arthroscopic risk factors for 90-d complications.

| Variable     | OR (95% CI) | P value |
|--------------|-------------|---------|
| Open DCE     | 1.73 (1.11-2.69) | .015*   |
| Arthroscopic DCE | 0.70 (1.09-1.31) | .479   |
| Female gender | 2.24 (1.07-4.68) | .032   |
| CHF          | 3.12 (1.46-6.64) | .003   |
| COPD         | 1.49 (0.96-2.32) | .072   |
| CKD          | 1.80 (1.18-2.73) | .005   |
| Diabetes     | 2.35 (1.37-4.02) | .002   |
| IHD          | 1.57 (1.05-2.34) | .032   |
| PHD          | 1.59 (1.12-2.24) | .005   |
| Tobacco use  | 1.42 (1.04-1.91) | .020   |
| Revision, n  | 861          | .126    |
| Arthroscopic DCE | 6             | .70     |
| Revision, n  | 1587         | 1.39    |

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; IHD, ischemic heart disease; PHD, pulmonary heart disease; *Diabetes, pulmonary heart disease; OR, odds ratio; CI, confidence interval.

*Indicates any value of P<.05.

Table III

Risk factors for 90-d complications after DCE.

| Variable     | OR (95% CI) | P value |
|--------------|-------------|---------|
| Open DCE     | 1.73 (1.11-2.69) | .015*   |
| Arthroscopic DCE | 0.70 (1.09-1.31) | .479   |
| Female gender | 2.24 (1.07-4.68) | .032   |
| CHF          | 3.12 (1.46-6.64) | .003   |
| COPD         | 1.49 (0.96-2.32) | .072   |
| CKD          | 1.80 (1.18-2.73) | .005   |
| Diabetes     | 2.35 (1.37-4.02) | .002   |
| IHD          | 1.57 (1.05-2.34) | .032   |
| PHD          | 1.59 (1.12-2.24) | .005   |
| Tobacco use  | 1.42 (1.04-1.91) | .020   |
| Revision, n  | 861          | .126    |
| Arthroscopic DCE | 6             | .70     |
| Revision, n  | 1587         | 1.39    |

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; IHD, ischemic heart disease; PHD, pulmonary heart disease; *Diabetes, pulmonary heart disease; OR, odds ratio; CI, confidence interval.

*Indicates any value of P<.05.

Limitations

There are several, well-documented, limitations to this study inherent to large national databases such as PatientDiver.21,30 First, the accuracy of the information is directly related to the accuracy of the coding process, as ICD and CPT codes were used to query the data. Second, the database is unable to define whether or not the procedure captured was truly a primary DCE. It is also possible that a patient had a DCE performed before being under Humana coverage. Third, patient-reported outcomes are not documented in these concordant procedures were not significantly associated with complications in either the open or arthroscopic cohort.

Several studies have reported the complication rates associated with both open and arthroscopic DCE. However, the reported incidence of complications vary widely in the literature, likely as a result of different sample sizes in available studies and varied definitions of postoperative complications. In studies that have examined the complication rate of open DCE, complications including infection, postoperative pain or weakness, stiff shoulder, residual AC joint sensitivity, scar sensitivity, and hypertrophic scar formation have been reported to range from 0% to as high as 64.41,7,9,11,13,17–19,26,28,29,34,35,39,41. The range of complication rates after arthroscopic DCE has been similarly broad, ranging from 0% to 33.3%.3,5,13,14,16,20,23,36,38,41 Our investigation found that overall complication rates for both arthroscopic and open DCE were low. However, a significantly greater incidence of postoperative complications within 90 days of surgery was seen in patients undergoing open DCE. To our knowledge, this is the first study that has directly compared complication rates of open and arthroscopic DCE. Most notably, 1.9% of patients who underwent open DCE developed an SSI compared with 0.3% in those managed arthroscopically. In addition, patients who underwent open DCE were three times more likely to suffer a wound disruption. Although rare, those undergoing open DCE were four times more likely to suffer a postoperative hematoma and six times more likely to suffer a postoperative transfusion relative to arthroscopic DCE.

Previous investigations have cited concerns over limited visualization with the arthroscopic approach, which could compromise an effective and complete DCE. An incomplete excision would, in turn, result in persistent pain and dysfunction necessitating revision surgery.24,27 We observed that the percent of patients requiring a revision surgery within 5 years of their DCE was 0.70% and 1.39% for open and arthroscopic approaches, respectively. The rate of revision was not significantly different (P = .126) for these groups.

The economic comparison of open vs. arthroscopic DCE remains poorly elucidated. Authors who advocate for the economic superiority of the arthroscopic approach cite the fact that the arthroscopic approach may be performed in an outpatient setting and allows for faster return to employment, whereas the open approach may require an inpatient stay and longer employee disability.25 Alternatively, arthroscopic procedures often require longer setup times and expensive instrumentation.27 A more recent study by Robertson et al found no significant difference in operation times between the open and arthroscopic DCE.33 Our investigation examined the total reimbursement for the day of surgery within the Humana database and found no significant differences in the reimbursement amounts between open and arthroscopic DCE. However, observed reimbursement rates may be confounded by the fact that concurrent procedures such as SAD and BT are frequently performed with DCE, especially when performed arthroscopically.
operate time, time under anesthesia, incision size, and rehabilitation protocol were not available within the database.

Conclusion

Both arthroscopic and open DCE techniques were found to have similar reimbursement amounts, with a low rate of complications, although the open technique had a higher rate of early complications such as SSI. Over the study period, there was an increase in the utilization of arthroscopic DCE, while the incidence of the open technique remained constant.

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