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Cost comparison of arthroscopic rotator cuff repair with arthroscopic vs. open biceps tenodesis

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Purpose: To use a nationwide database to determine differences in cost between patients who underwent arthroscopic rotator cuff tear with open vs. arthroscopic biceps tenodesis (BT).

Methods: The 2014 State Ambulatory Surgical and Services Databases from 6 US states was utilized. All cases with CPT codes 29827 (arthroscopic rotator cuff repair [RCR]) and either 23430 (tenodesis of long tendon of biceps) or 29828 (arthroscopic BT) were selected. Cases that included both 23430 and 29828 were excluded, as were those missing demographic data. Generalized linear models were used to model costs based on the surgical and patient variables that were significant in the initial bivariate analysis ($P < .05$).

Results: A total of 3635 RCR and BT cases were identified. There were 2847 (78.3%) with arthroscopic BT and 788 (21.7%) with open BT. Patients undergoing arthroscopic BT were 3.1 years older than patients undergoing open BT ($P < .001$). For arthroscopic BT, 39.2% of the cases were women compared with 22.6% of the open cases ($P < .001$). For operative variables, arthroscopic BT required 9 fewer minutes in the OR than open cases ($P = .002$). Concomitant distal clavicle resection was performed in 35.5% of arthroscopic BT cases compared with 29.8% of open cases ($P = .004$). While controlling for other significant factors, open BT was associated with $5542 lower costs than arthroscopic BT in the setting of RCR ($P < .001$). In either case, concomitant subacromial decompression added $10,669 ($P < .001$), and distal clavicle resection added $3210 ($P < .001$). High-volume surgical facilities were associated with $4107 lower costs ($P < .001$).

Conclusions: In a large series of patients undergoing arthroscopic RCR with open vs. arthroscopic BT, open BT was associated with $5542 lower costs than arthroscopic. Given that both techniques have been shown to be similarly effective in long-term follow-up, surgeons should be aware of opportunities for cost saving, particularly with the advent of bundled surgical reimbursements.

Level of evidence: Level IV; Economic Analysis using Large Database

Keywords: arthroscopy; rotator cuff; biceps tenodesis; cost analysis

The long head of the biceps tendon (LHBT) originates from the supraglenoid tubercle and superior labrum.[9] The close proximity of the LHBT to the supraspinatus and subscapularis tendons predisposes it to damage in the setting of rotator cuff pathology.[19] In fact, up to 90% of cases of LHBT pathology are associated with rotator cuff tears.[3] Recent studies have demonstrated that the incidence of rotator cuff repair (RCR) is increasing, along with an associated increase in concomitant biceps tenodesis (BT).[15,18] Men have been reported to be twice as likely to

Institutional review board approval was not required for this economic analysis.

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undergo RCR with BT as women, and the operation is most commonly done in the middle-age population.[15,18] Failure to treat underlying biceps tendon pathology in patients with rotator cuff tears can lead to persistent shoulder pain and poor patient satisfaction. Historically, open BT was the standard of care; however, in recent years, arthroscopic BT has gained increasing popularity as arthroscopic surgical techniques continue to improve.[18]

Previous studies demonstrate that the total overall rate of arthroscopic BT and tenodesis in general is rising.[15,18] Vellios et al[18] used the PearlDiver database from 2007 to 2011 and found that despite the percentage of BT performed via an open approach decreasing from 99.8% to 56.5% that the number of open cases still increased annually over the time period, albeit not at the same rate as arthroscopic. Both arthroscopic and open tenodesis have been shown to be effective treatments for LHBT injury, with neither technique demonstrating superior results, although an argument can be made that arthroscopic tenodesis is more cosmetic.[4,7,14] Although concomitant pathology and technical considerations may influence surgical technique, the approach, whether arthroscopic or open, is ultimately decided by the surgeon. Given the clinical equivalency of the 2 approaches, one factor that may ultimately sway a surgeon's decision is cost.

As medical reimbursement shifts toward bundled payments, and as surgeon- and clinical practice–owned surgery centers continue to increase, cost is a real-life consideration in the treatment of surgical conditions, especially if all else is considered equal. There is a paucity of literature on cost analysis with regard to open vs. arthroscopic BT. Therefore, the present study aims to augment current literature and educate physicians to the cost-benefits of open vs. arthroscopic BT. Because patient outcomes status post open arthroscopic BT are roughly equivalent, there is utility in understanding how costs can be reduced for payers, both individual and commercial alike. We hypothesize that open BT will be a less expensive alternative to arthroscopic BT.

Methods

Data source

This study is a retrospective cohort study using the State Ambulatory Surgery and Services Databases from 2014 (January 1 until December 31). These databases are part of the Healthcare Cost and Utilization Project, which provides the largest source of hospital care data in the United States.[2] Databases from 6 US states were used: Florida, Iowa, Kentucky, Maryland, New York, and Nevada. This sampling of states has been used in previous studies and is thought to be generalizable to the US population as a whole.[5,11] These databases contain encounter-level information on variables, including patient demographics, Current Procedural Terminology (CPT) codes, expected payment source, and total charges. All cases with CPT codes 29827 (arthroscopic RCR) and either 23430 (tenodesis of long tendon of biceps) or 29828 (arthroscopic BT) were selected. Cases that included both 23430 and 29828 were excluded, as were those missing demographic data.

Outcome measures

The primary outcome assessed in this study is total charges. This is used as a proxy variable for cost of surgery. Although total charges reflect the amount billed by a surgeon and not the amount paid by insurers or patients, they have been shown to be a helpful proxy for cost in previous studies of common orthopedic procedures, including arthroscopic RCR.[5,10,11] Other measures that were assessed include demographics such as patient race, sex, age, comorbidity level, and US state. Surgical variables included operative time, surgical facility caseload, postoperative admission to the hospital, concomitant subacromial decompression, and concomitant distal clavicle resection. Subacromial decompression was assessed using CPT code 29826, and distal clavicle resection was assessed using CPT code 29824 (Mumford procedure).

Statistical analysis

Demographic and operative variables were first analyzed for differences between the open and arthroscopic BT groups. Statistical testing included chi-square and 1-way analysis of variance. Variables that differed significantly between the 2 groups were then entered into a generalized linear model (GLM) with total charges as the outcome. This allowed for comparison of open and arthroscopic BT with RCR while controlling for other significant variables. It should be noted that surgical facility volume and operative time were included as continuous variables under bivariate analysis but were converted to categorical variables for analysis in the GLM. Facility volume was divided into high- and low-volume groups with at least 25 cases per year as the cutoff. This was selected as it was the closest round number to the median caseload. Operative time was divided into quartiles. It was also only available for cases from New York, so an indicator variable for missing data was included in the model to assess for resulting bias. Subacromial decompression, although not performed at statistically significant rates between groups ($P = .089$), was included in the GLM because it was approaching significance under bivariate analysis. P values less than .05 were considered statistically significant (SPSS Statistics V25.0; IBM Corporation, Armonk, NY, USA).

Results

After exclusions, there were 3635 RCR and tenodesis cases. There were 2847 (78.3%) cases of arthroscopic RCR with arthroscopic BT, and 788 (21.7%) cases of arthroscopic RCR with open BT.

Bivariate analysis

Significant differences between the arthroscopic and open BT groups with arthroscopic RCR were found for patient demographics (Table I). Patients undergoing arthroscopic BT were 3.1 years older than patients undergoing open BT

Table I Bivariate analysis comparing demographic and surgical factors between open biceps tenodesis and arthroscopic biceps tenodesis in the setting of rotator cuff repair

Parameter	Arthroscopic BT	Open BT	*P* value
Categorical variables (95% CI)			
Age, yr	59.9 (59.5-60.3)	56.8 (56.1-57.4)	<.001
Operative time, min	114 (110-118)	123 (119-127)	.002
Mean facility caseload, n	41 (39-43)	38 (45-52)	<.001
Cost, $	32,461 (31,747-33,174)	21,013 (19,910-22,116)	<.001
Hospital admission rate	3.4 (2.7-4.0)	2.7 (2.6-3.8)	.320
Race			
White	81.0	76.9	<.001
Black	6.6	5.6	
Hispanic	7.4	4.8	
Asian	0.8	0.6	
Other	4.1	12.1	
Sex			
Male	60.8	77.4	<.001
Female	39.2	22.6	
State			
Florida	89.1	10.9	<.001
Iowa	86.7	13.3	
Kentucky	73.7	26.3	
Maryland	70.9	29.1	
Nevada	90.7	9.3	
New York	61.4	38.6	
Concomitant procedures (95% CI)			
Distal clavicle resection	35.5 (33.7-37.3)	29.8 (26.5-33.1)	.004
Subacromial decompression	78.4 (76.9-80.0)	81.2 (78.5-84.0)	.089
Number of comorbidities			
None	37.5	35.7	.338
At least 1	62.5	64.3	

CI, confidence interval; *BT*, biceps tenodesis.
Values are percentages unless otherwise noted.

($P < .001$). White patients made up 4.1% more of the sample in the arthroscopic group than the open group ($P < .001$). For arthroscopic BT, 39.2% of the cases were women compared with 22.6% of the open cases ($P < .001$). Rates of arthroscopic vs. open BT also varied by state. In Nevada, 90.7% of cases were performed arthroscopically, whereas only 61.4% of cases in New York were arthroscopic ($P < .001$). Arthroscopic BT was associated with significantly higher costs, averaging $31,461 per case vs. $21,013 for the open procedure ($P < .001$). Comorbidity level was not significantly different between the arthroscopic and open BT groups ($P = .338$).

For operative variables, arthroscopic BT cases required 9 fewer minutes in the OR than open cases ($P = .002$). Mean surgical facility caseload was 3 cases higher per year for arthroscopic BT ($P < .001$). Concomitant distal clavicle resection was performed in 35.5% of arthroscopic BT cases compared with 29.8% of open cases ($P = .004$). Neither the rate of postoperative admission ($P = .320$) nor the rate of concomitant subacromial decompression ($P = .089$) was significantly different between the 2 groups.

Generalized linear model

While controlling for other significant factors, open BT was associated with $5542 lower costs than arthroscopic BT in the setting of RCR assuming all other variables are held equal (Table II; $P < .001$). Concomitant subacromial decompression added $10,669 ($P < .001$), and distal clavicle resection added $3210 ($P < .001$), irrespective of case performed. Longer operative times were also associated with increased costs. Cases in the highest quartile of operative time were associated with $11,551 more in costs than cases in the lowest quartile ($P < .001$). Smaller differences of $8249 and $4338 were found for the third and second quartiles, respectively (both $P < .001$). Notably, the indicator variable for cases missing operative time data was not a significant factor in the GLM ($P = .852$). High-volume surgical facilities were associated with $4107 lower costs ($P < .001$), and female sex was associated with $1339 lower costs ($P = .012$). Older age was associated with $82 lower costs per year ($P = .002$). Costs also varied significantly by state. Florida was the reference category and was

Table II Generalized linear model of cost comparing open to arthroscopic biceps tenodesis while controlling for all other significant factors in the setting of rotator cuff repair

Parameter	Cost	95% confidence interval		*P* value
		Lower	Upper	
Biceps tenodesis method				
Intercept	36,794	23,155	50,433	<.001
Open	−5542	−6817	−4267	<.001
Arthroscopic	Reference			
Subacromial decompression				
Performed	10,669	9430	11,908	<.001
Not performed	Reference			
Distal clavicle resection				
Performed	3210	2129	4291	<.001
Not performed	Reference			
Operative time quartile				
Fourth	11,551	9113	13,988	<.001
Third	8249	5822	10,676	<.001
Second	4338	1902	6773	<.001
First	Reference			
Operative time data				
Missing	1262	−12,007	14,531	.852
Surgical facility volume				
High volume	−4107	−5121	−3093	<.001
Low volume	Reference			
Sex				
Female	−1339	−2380	−297	.012
Male	Reference			
Hospital state				
New York	−23,712	−36,891	−10,533	<.001
Nevada	−4214	−6797	−1632	.001
Maryland	−29,376	−31,440	−27,311	<.001
Kentucky	−12,306	−15,192	−9420	<.001
Iowa	−14,725	−18,241	−11,208	<.001
Florida	Reference			
Continuous variables				
Age	−82	−133	−31	.002

All values are in 2014 US dollars.
Patient race was included but not significant.

associated with the highest costs. Maryland had the lowest costs of any state, with a reduction of $29,376 over cases performed in Florida ($P < .001$).

Discussion

Similar to other studies that have shown a rising popularity in arthroscopic BT, the present study found that 78% of arthroscopic rotator repairs that involved a BT were done so arthroscopically.[18] Within this group of RCR with arthroscopic BT, 39.2% of patients were women, compared with 22.6% women in the arthroscopic RCR with open BT group. When controlling for all other significant variables, open BT saved $5542 compared with arthroscopic BT, despite being 9 minutes longer on average.

With advances in arthroscopic treatment, arthroscopic BT has become more common.[18] Although both biceps tenotomy and tenodesis have traditionally been used in the middle-aged patient population undergoing RCR, studies have found trends toward greater patient satisfaction and improved cosmesis following BT.[1,6,12] This is particularly true in female patients, and interestingly, this study found that arthroscopic BT was more commonly performed on women, as this can eliminate the additional incision needed for the more traditional open procedure.[13] On the other hand, the decision to perform BT open vs. arthroscopic remains controversial. In a series of 71 patients undergoing arthroscopic RCR with BT, Yi et al[20] found improved American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form scores at 2 weeks and superior visual analog scores at 2 weeks and 3 months for the open

BT group compared to arthroscopic. They also found that open BT procedures were shorter on average, which contrasts our finding of open BT taking 9 additional minutes of operative time.[20] In contrast to Yi et al, other studies have shown no significant difference in long-term patient-reported outcomes or pain following arthroscopic RCR with open vs. arthroscopic BT.[8,13]

Although several authors have attempted to quantify the impact of different variables on costs associated with RCR, no known studies have directly compared the cost of open vs. arthroscopic BT.[11,13] In a study looking at middle-aged patients with superior labral tears, Paoli et al[16] used a Markov cost analysis to show that primary open BT saved $1700 on average compared to arthroscopic labral repair, particularly when considering the added costs of revision surgery. Although this patient population is inherently different from the RCR population studied here, both studies share a similar finding of added cost savings with open BT.[16] In contrast, here we found added cost savings of $5542, which is significantly larger than that reported by Paoli et al.[16] In another study of costs associated with RCR, Tashjian et al[17] found that an added number of suture anchors was a significant cost driver, although the authors did not compare open vs. arthroscopic BT directly. Although it is not entirely clear why open BT provides such a degree of cost savings, it is possible that the use of bone tunnels with an open approach could provide cost savings, particularly if fewer suture anchors are used. In addition, open procedures likely require less open surgical equipment with regard to disposable instruments and even additional trays that may need to be opened and processed.

Besides arthroscopic BT, several other variables were found to be predictors of higher cost in the setting of RCR. Similar to previous cost analyses, here we found that older age, concomitant subacromial decompression, and concomitant distal clavicle resection were all independent drivers of added cost, even when accounting for the added operative time.[11] This may be a direct result of the added surgical equipment required to perform these procedures. Finally, surgeries that were performed and higher-volume surgery centers also provided a degree of cost savings in keeping with previous research.[16] This may be a result of the efficiency that ultimately comes with staff members who are trained and familiarized with arthroscopic equipment.

Limitations

Despite using a large and geographically representative database, there are limitations to this study. As is inherent with any large database studies, it is possible that misclassified data can introduce a source of bias. Because of the lack of granularity inherent to these databases, we were unable to further specify how arthroscopic or open BT were performed, along with the treatment and severity of the associated RCR. Additionally, this extends to an inability to classify the surgical devices and implants used and what quantity they were used in, which could create a great deal of variability based on hospital and surgery center contracts with vendors. Furthermore, because there may be differences in coding and billing practices between providers, the charges calculated here may not be identical with the cost ultimately received. For example, some surgeons may not bill for each anchor separately, thus deflating the overall cost. Additionally, surgeons performing arthroscopic BT likely required more surgical instrumentation (anchors, suture passers, additional suture), which was not captured by the database. Reimbursement, both for the case and with regard to surgeon RVU (relative value unit), and the charges collected may also differ from charges as this can depend heavily on local contract agreements negotiated between the specific manufacturers and surgery centers. Despite the limitations noted here, the State Ambulatory Surgery and Services Databases has been previously validated as useful database for cost analysis following RCR surgery and has been used a cost analysis tool for many other orthopedic procedures.[5,10] Furthermore, given the lack of clarity regarding the surgical efficacy of open vs. arthroscopic BT in the setting of arthroscopic RCR, surgeons should be aware of the potential cost savings associated with open BT, particularly with the advent of bundled payments for surgical reimbursement.

Conclusion

In a large series of patients undergoing arthroscopic RCR with open vs. arthroscopic BT, open BT was associated with $5542 lower costs than arthroscopic BT. Given that both open and arthroscopic BT have been shown to be similarly efficacious in long-term follow-up, surgeons should be aware of opportunities for cost saving, particularly with the advent of bundled surgical reimbursements.

Disclaimer

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