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Distal biceps tendon repair: cost analysis of single- versus double-incision techniques in an ambulatory surgery center

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Background: The purpose of this study was to compare the cost differences for single- versus double-incision distal biceps repair at an ambulatory surgery center (ASC) given that similar clinical outcomes have been reported between these methods.

Methods: A retrospective review of financial and medical records was completed for patients who underwent distal biceps tendon repair over a three-year period at a single private orthopedic practice. Variables analyzed include the cost to the ASC of operative time and the cost of differential surgical supplies, specifically implants and disposable supplies.

Results: A total of 10 surgeons performed 104 repairs. Nine surgeons performed repairs through a single incision with use of cortical button or suture anchor fixation, and one surgeon performed transosseous suture fixation through a double-incision approach. The median tourniquet time and procedure length were 31 (interquartile range [IQR] 27-40) and 44 (IQR 39-54) minutes for single-incision repairs and 68 minutes (IQR 61-75) and 110 minutes (IQR 103-113) for double-incision repairs which were significantly different across groups ($P < .001$, $P < .001$). The total surgical cost (operative time, implants, and disposables) for single-incision repairs was a median of $758 (IQR 732-803) compared with $606 (IQR 567-629) for double-incision repairs ($P < .001$). However, the procedure cost with implants (not including disposables) was not significantly different for single- (median [Mdn] = $500 [IQR 475-552]) and double-incision repairs (Mdn $552 [IQR 514-564]) ($P = .14$) although the procedure cost with disposables (not including implant costs) favored single-incision repairs (Mdn = $478 [IQR 452-523]) over double-incision repairs (Mdn = $606 [IQR 567-629]) ($P < .001$).

Conclusion: In a single surgery center, single-incision distal biceps repairs utilizing an implant were performed more expeditiously than double-incision repairs with a transosseous technique but incurred greater surgical costs. Differences in surgical time cost between the two approaches could be consequential for ASCs and other stakeholders.

Rupture of the distal biceps results in significant losses to flexion and supination strength at the elbow if left untreated, whereas surgical repair of the tendon can restore these strength parameters and is routinely advocated for young and active patients.[6,10] Various methods of distal biceps repair have been the subject of extensive research, but currently, there is no consensus on the clinical superiority of one approach or fixation method over the other.[1,3,8,10-12,15]

Historically, distal biceps repair was performed through an extensile anterior approach which carried a high risk of nerve complications. In the early 1960s, Boyd and Anderson published a two-incision technique to mitigate these risks, but encountered problems with limited forearm rotation due to synostosis related to subperiosteal dissection of the ulna.[2] Morrey eventually modified Boyd and Anderson's two-incision technique, by using a transmuscular posterior approach to decrease the risk of this complication.[9] Morrey's modified approach subsequently gained popularity; however, recently, there has been a shift back to single anterior incisions performed through a more minimally invasive approach with use of various implants for fixation.[3,9]

A multitude of comparative studies have demonstrated similar outcomes between modern single- and double-incision

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

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approaches.[1,3,8,17] In the absence of strong clinical evidence in favor of one method, an analysis of other factors, namely, surgical time and cost, might help supplement decision-making. Therefore, the purpose of this study was to compare cost differences for single- versus double-incision distal biceps repairs performed at a single ambulatory surgical center.

Materials and methods

A retrospective review was performed to identify all patients who underwent distal biceps repair at a physician-owned ambulatory surgery center (ASC) from September 2014 to December 2017. The study period included all the cases performed with two-incision approaches from the start of the senior author's practice until the time of study initiation. The inclusion criterion was a surgical repair coded with CPT 24342 in the electronic medical record. No cases were excluded; however, all patients were over 18 years of age, none required graft augmentation, and none were revision procedures.

Financial records were compiled for each case to include all data relevant to a comprehensive cost analysis. Cost data were provided by the outpatient surgical center's chief financial officer. Given the similarity of the two procedures, the fixed costs for each procedure were not included (eg, processing of nondisposable surgical sets). The main independent variables analyzed were the costs of disposable surgical sets and implants, other single-use disposable instruments, and the cost of the operating room based on procedure duration. Procedure duration was defined as the time out of minus the time into the operating room. The operating room cost was obtained by multiplying the recorded procedural time by $5 per minute. $5 per minute was derived from the billable total cost of $300/hour for the operating room. The electronic medical record was reviewed for demographic information and operative details.

The usefulness and validity of a cost analysis depend on the perspective from which it is performed because different costs for an operation affect involved parties in different ways. The contingents include patients, surgeons, the ASC, and the payer as shown in Table I. In the present study, the authors sought to examine cost primarily from the perspective of the ASC. Therefore, certain costs that might have varied between the operations but were not paid by the ASC (eg, anesthesiologist professional fees) were not included in the analysis.

Statistical methods

Statistical analyses were conducted in R, version 3.6.2, using the RStudio integrated development environment.[13,14] The tidyverse[18] and janitor[5] packages were used to transform data before analysis. Continuous variables are reported as median and interquartile range (IQR), and categorical and ordinal variables are reported as proportions of the total cohort. Procedure and total surgical cost comparisons were evaluated using Wilcoxon signed-rank tests, with a nominal α set at 0.05, using the gtsummary package.[16] Implant costs were treated as a categorical variable and were compared using Fisher's exact test.

Results

Ten surgeons performed 104 distal biceps repairs on 103 patients over the three-year study period. Patients underwent surgery at a median of 16 (IQR 8-31) days from injury, and 75% had a complete distal biceps tendon repair noted at the time of surgery. Table II summarizes the relevant demographic data for the study patients.

Table I
Financial stakeholder matrix

Stakeholder	Procedure length	Implant cost	Disposable cost
Third-party payer	No	Yes*	No
ASC	Yes	Yes*	Yes
Surgeon	Yes	No*	Yes†
Patient	Yes	Yes‡	No
Health care system	Yes	Yes	Yes

ASC, ambulatory surgery center.
*Dependent on the contract between the payer and ambulatory surgery center (ASC).
†Surgeons in physician-owned ASCs are incentivized to limit nonreimbursable costs.
‡Patients responsible for co-pays could be impacted by payer implant costs.

Nine surgeons performed 92 repairs through a single anterior incision, whereas one surgeon performed 12 double-incision repairs. For the single-incision repairs, the median procedure length was 44 (IQR 39-54) minutes, with a median tourniquet time of 31 (IQR 27-40) minutes, whereas the median procedural length and tourniquet time for double-incision repairs were 110 (IQR 103-113) and 68 (IQR 61-75) minutes, respectively. Procedure length ($P <$ .001) and tourniquet time ($P <$ .001) were significantly different between single-incision and double-incision repairs. There was no difference in operative time noted for partial (52 ± 28 mins) or complete tears (48 ± 12 mins) undergoing single-incision repairs ($P =$ .33). Eight surgeons in the single-incision group utilized a cortical button for tendon fixation, whereas one surgeon in the single-incision group utilized a metal suture anchor in each of three cases. The surgeon performing a two-incision approach utilized a transosseous suture technique negating the need for an implant and its associated costs.

Overall, the median total surgical cost (including disposable supplies, implants, and procedure time cost) was $748 (IQR 718-793) with single-incision repairs ($758 [IQR 732-803]) being significantly more expensive than their double incision ($606 [IQR 567-629]) counterparts ($P <$ .001). The median cost of the procedure with disposables (not including implants) was $483 (IQR 453-544) with a significant difference noted between single-incision ($478 [IQR 452-523]) and double-incision repairs ($606 [IQR 567-629]) ($P <$ .001); however, no difference was noted for procedure cost with implants (not including disposables) for single- ($500 [IQR 475-552]) and double-incision repairs ($552 [IQR 514-564]) ($P =$ .14) (Table III).

Complications included 28 (27%) total instances of lateral antebrachial cutaneous nerve paresthesias after surgery. Other less frequent complications included one transient posterior interosseous nerve palsy, one patient with local numbness distal to a single transverse incision, one patient with mild supination loss, and one patient with transient dorsal distal arm paresthesias after a double-incision repair. Routine follow-up radiographs were not routinely obtained; however, heterotopic ossification was incidentally noted postoperatively in two patients who underwent single-incision repairs with otherwise normal postoperative range of motion. Finally, no infections, re-ruptures, or revision surgeries were reported at the final follow-up.

Discussion

In this study, at a single ASC, single-incision distal biceps repairs using implants were performed significantly faster but at greater cost than double-incision repairs without implants; however, the implications of these findings are complex. For example, from an ASC administrator's perspective, a two-incision repair without implants might have a lower cost to the ASC if implants are not

Table II
Demographic data for single- and double-incision repairs

Characteristic	Overall, N = 104	N	Single incision, N = 92*	Double incision, N = 12*
Age	48 (43, 56)	104	48 (43, 56)	51 (45, 56)
Sex		104		
Male	100 (96%)		88 (96%)	12 (100%)
Female	4 (3.8%)		4 (4.3%)	0 (0%)
Dominant arm rupture	39 (46%)	85	33 (45%)	6 (50%)
Unknown	19		19	0
Complete rupture		103		
Complete	77 (75%)		65 (71%)	12 (100%)
Partial	26 (25%)		26 (29%)	0 (0%)
Unknown	1		1	0
Work related	55 (53%)	103	48 (53%)	7 (58%)
Unknown	1		1	0
Time to Surgery (days)	16 (8, 31)	100	16 (8, 31)	15 (8, 25)
Unknown	4		4	0

*Statistics presented: median (IQR); n (%).

Table III
Single- and double-incision repair cost profiles

Characteristic	N	Overall, N = 104	Single incision, N = 92*	Double incision, N = 12*	*P* value†
Implant costs (USD)	104				<.001
0		12 (12%)	0 (0%)	12 (100%)	
242.25		2 (1.9%)	2 (2.2%)	0 (0%)	
280.25		90 (87%)	90 (98%)	0 (0%)	
Procedure cost with disposables (USD)	104	483 (453, 544)	478 (452, 523)	606 (567, 629)	<.001
Procedure cost with implants (USD)	104	508 (479, 558)	500 (475, 552)	552 (514, 564)	.14
Total surgical cost (USD)	104	748 (718, 793)	758 (732, 803)	606 (567, 629)	<.001

*Statistics presented: n (%); median (IQR).
†Statistical tests performed: Fisher's exact test; Wilcoxon rank-sum test.

separately billable to the payer (eg, the ASC does not pay this cost). However, if implants are billed separately to the payer, then the single-incision technique would clearly have superiority based on both cost and operative time. Even if the ASC was responsible for the implant cost, there exists an indirect financial benefit for surgeons and surgery centers of an hour decrease in operative time because an extra procedure could potentially be added to the day during normal business hours. From the health care system and payer perspective, single-incision repairs with anchors may be disfavored based on total surgical cost. If the patient is paying directly for the procedure or if a portion of the direct cost is passed down to the patient, the two-incision without implant approach may be favored. Higher nonreimbursable costs are also directly relevant to surgeons who have ownership in the ASC where they may be incentivized to lower these costs.

One previous study comparing suture anchors (single incision) and transosseous suture fixation (double incision) had findings counter to the present study, with no difference noted in operative times.[7] Correspondingly, the authors concluded that the cost of the implants was not negated by the operative time cost savings. In contrast, the present study highlights the potential for large differences in operative times (and associated costs) in the single-incision group with utilization of an implant. However, as the authors note in the study by Grant et al, intersurgeon variation may also play an important role in this parameter, although a more recent granular cost analysis on single-incision distal bicep repairs was unable to show a significant difference in this regard.[4,7] The recent cost analysis by Feller et al also did not find a significant difference between time to surgery or location (hospital vs. ASC) of surgery, but they highlighted an itemization of cost, with 30% going toward implants and 53% going toward facility fees, which provides a framework for future cost containment efforts.[4] This also validates the cost analysis model utilized in this study and the study by Grant et al given the small proportion of other direct costs (pharmacy, imaging, laboratory) not accounted for, especially given the limited variability between single- and double-incision approaches.[7]

Limitations

That a single surgeon's experience at the start of clinical practice represents the entirety of the double-incision group is a significant limitation to this study. However, Grant et al reported a mean operative time of 98 ± 15 minutes for the transosseous, double-incision group (2 surgeons, 28 cases), which is similar to that seen in the present study (1 surgeon, 12 cases).[7] The present study's double-incision tourniquet times are also similar to those from the study by Dunphy et al, corroborating their finding that single-incision tourniquet times were significantly less than double-incision tourniquet times.[3] Notably, Dunphy et al included 85 surgeons who performed 784 total repairs (145 double incision), with surgeons performing double-incision repairs having 13.8 years of experience, compared with 9.4 years for single incision ($P <$ .001). Finally, given the similarity of surgical setup for single- and double-incision repairs, the study focused on reporting on relevant differences in direct costs and did not fully delineate other indirect costs associated with differences in complications or operating room utilization.

Conclusion

In a single surgery center, single-incision distal biceps repairs utilizing an implant were performed more expeditiously than double-incision repairs with a transosseous technique but incurred greater surgical costs. Differences in surgical time cost between the two approaches could be consequential for ASCs and other stakeholders.

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