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Functional outcomes of distal triceps tendon repair comparing transosseous bone tunnels with suture anchor constructs

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Background: Distal triceps tendon ruptures are relatively rare. Few studies have investigated functional outcomes after repair. There is no consensus on fixation methods for this injury. The purpose of this study was to compare the functional outcomes and the reoperation rates after distal triceps tendon repairs using transosseous tunnels and suture anchors.

Methods: A multicenter, retrospective review of all primary triceps repairs done between 2006 and 2015 was performed. Patients were included if they had a minimum of 2 years of follow-up. Intraoperative data recorded included repair method and number of anchors used when applicable. Patients were contacted for functional assessment with the Mayo Elbow Performance Score (MEPS). Postoperative complications were also queried.

Results: There were 56 cases of primary triceps repair identified in an all-male cohort. Average age at time of surgery was 52.7 years; 58.9% of patients had transosseous repair, and 41.1% had suture anchor repair. The average follow-up was 4.26 years. The average postoperative MEPS score for all patients was 94. There was no difference in MEPS outcomes based on construct type. Postoperative Disabilities of the Arm, Shoulder, and Hand scores had an overall average of 4.81. A statistically significant difference was found, with the transosseous group averaging 2.98 points lower than the suture anchor group. This difference was not found to be clinically relevant. Only 4 patients had rerupture of the triceps requiring revision.

Work performed at the Rothman Institute, University of Utah, MedStar Union Memorial Hospital, Twin Cities Orthopaedics, and Orthopaedic and Neurosurgery Specialists.

The Institutional Review Board of Thomas Jefferson University approved this study: Board #2405; Control #15D.622.

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Conclusions: Primary repair of distal triceps tendon ruptures yields good, durable patient outcomes with minimal rerupture regardless of repair construct.
Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Triceps rupture; distal triceps; transosseous repair; suture anchor repair; MEPS; functional outcomes; triceps rerupture

Acute ruptures of the distal triceps tendon are a relatively rare injury.[10,14] These injuries generally occur in middle-aged men after forceful eccentric elbow extension.[1,4,11,13] In general, tears of >50% of the tendon insertion are treated surgically.[1,4,8,15,16] Various repair methods have been described in the literature with the aim of restoring the normal tendon footprint insertion. These repair methods include use of transosseous bone tunnels with nonabsorbable suture, use of suture anchors in the olecranon, and hybrid fixation with both bone tunnels and suture anchors.[4,15,16]

The literature investigating distal triceps tendon repairs is limited. Most studies represent small case series that focus on postoperative range of motion and strength levels.[1,3,8,11,13,15] Very little is published about functional outcomes after repair, mostly because of the small number of patients investigated. In addition, there is no consensus on the optimal method of fixation. Yeh et al compared biomechanical properties of repairs, concluding that anatomic repair with a double-row suture bridge using suture anchors resulted in the least amount of displacement compared with repairs isolated with suture anchor or transosseous tunnels.[16]

The purpose of this study was to review and to compare the functional outcomes and the reoperation rates after distal triceps tendon repairs using transosseous tunnels and suture anchors. We hypothesized that patients would experience similar functional outcomes, complications, and retear rates regardless of fixation method.

Materials and methods

We performed a multicenter, retrospective cohort study of all patients undergoing repair of the distal triceps tendon between 2006 and 2015. Five centers were involved in this study, including the following number of surgeons from each site: Rothman Institute at Thomas Jefferson University (Philadelphia, PA, USA), 5 surgeons; University of Utah (Salt Lake City, UT, USA), 1 surgeon; MedStar Union Memorial (Baltimore, MD, USA), 1 surgeon; Twin Cities Orthopaedics (Minneapolis, MN, USA), 1 surgeon; and Orthopaedic and Neurosurgery Specialists (Greenwich, CT, USA), 1 surgeon. Patients were eligible for inclusion if they were at least 18 years of age and had a minimum of 2 years of follow-up. Patients were excluded if they had incomplete records of surgical and clinical data and if their surgery was performed in the setting of elbow arthroplasty, infection, and open traumatic ruptures.

Demographic data including age, gender, and operative side were collected from preoperative medical records. Operative reports were queried for information about repair method used (tunnels vs. suture anchors). Postoperatively, patients' records were investigated for any complications, such as wound infection or retear. All patients were also contacted by telephone by independent members of the research team for functional assessment using the Mayo Elbow Performance Score (MEPS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. For the MEPS scoring criteria of range of motion and instability, definitions were carefully described to the patients. Range of motion was described as <50°, between 50° and 100°, and >100°; any confusion was clarified with description of simple household tasks that would require these range of motion parameters to determine what arc patients were capable of achieving. Instability symptoms were described to patients, and they were asked if such symptoms existed. Because these triceps injuries were in isolation, the concern for elbow instability was at a minimum. Patients were also asked to answer visual analog scale (VAS) questions about satisfaction and pain after surgery and if they were satisfied with the surgery and would have the surgery again if needed. The primary outcome measure was the MEPS. Secondary outcome measures included the DASH score, the pain score, the patient's satisfaction, the patient's willingness to have the operation again, and the rate of tendon rerupture. Tendon rerupture was initially based on the patient's symptoms and then verified by physical examination maneuvers consistent with tendon tearing (ie, palpable defect, inability to extend arm against gravity overhead). All patients with rerupture underwent imaging again with magnetic resonance imaging (MRI) and ultimately revision repair.

Surgical technique

All repairs regardless of construct are performed in the lateral decubitus position with the operative extremity draped over a lateral arm positioner. General anesthesia or regional block with muscle relaxation is provided. A well-padded tourniquet is placed high on the operative extremity and if necessary inflated to 250 mm Hg. A longitudinal, posterior incision is used, with the incision guided just lateral to the tip of the olecranon. Subcutaneous flaps are raised both medially and laterally with care to avoid the ulnar nerve. The distal aspect of the triceps tendon is identified and mobilized from the subcutaneous tissue with care to avoid the radial nerve if there is significant retraction. The distal triceps is débrided and freshened using a combination of rongeurs, scalpels, and curets. Areas of delamination are identified for proper repair incorporation. Any bone enthesophyte within the distal portion of the tendon is excised. The triceps olecranon insertion footprint is also débrided and decorticated to allow a healthy, bleeding bone bed.

Transosseous repair

Two cruciate tunnels and 1 transverse tunnel are placed through the olecranon. Shuttle sutures are placed through the crossing tunnels. One or 2 sutures of No. 2 or No. 5 FiberWire (Arthrex, Naples, FL, USA) were placed along the length of the tendon in a Krackow fashion. The suture ends are shuttled through the cruciate tunnels in a proximal to distal fashion. Another No. 2 FiberWire is passed through the transverse tunnel and placed in a purse-string fashion through the edge of the triceps tendon. The cruciate tunnel suture ends are then tied over the bone bridge between the 2 distal exit holes of the tunnels while the elbow is held in extension, followed by the purse-string stitch.

Suture anchor repair

Suture anchor repair constructs varied. The most common construct consisted of 2 suture anchors placed in the proximal portion of the triceps tendon footprint, with 1 anchor medial and the other lateral. The suture limbs from the anchors are then sutured through the tendon in either a Krackow or horizontal mattress pattern. The suture limbs are left long and placed through either a single third anchor or 2 distal ulna anchors that are placed more distal within the anatomic footprint to allow a double-row type of repair. This third anchor is seated securely with the elbow held in extension. In the case of a hybrid repair, the proximal-row anchor sutures are tied over a distal transverse transosseous tunnel in place of a distal anchor.

In addition, there were 4 cases of suture anchor repair in which only a single row of anchors was used. These anchors were placed in a medial and lateral fashion similar to the proximal row of a double-row repair. However, the placement of the anchors was more centered within the proximal to distal dimension of the triceps footprint.

Statistical analysis

Data analysis was done comparing outcome measures to detect noninferiority of the outcome scores between patients in whom repair was done with suture anchors and patients in whom repair was done with transosseous tunnels. Continuous variables were analyzed using a Student *t*-test, and categorical variables were analyzed using a χ^2 test or Fisher exact test. A *P* value of .05 was set as statistically significant. For this analysis, a power analysis with a 1-sided α of .05 and β of .90 to detect a noninferiority limit of 10 points in the MEPS score was done. This power analysis found that at least 18 patients in each group were needed to prove noninferiority between the surgical constructs. A second analysis was performed in a case-control fashion comparing the outcome measures on the basis of whether patients sustained a rerupture and required revision surgery. All data analysis was done using SPSS software (IBM Inc, Armonk, NY, USA).

Results

Overall, 101 patients with 102 distal triceps repairs were treated during the study period. Of this cohort, 55 patients with 56 distal triceps repairs were available for appropriate follow-up (Table I). All patients were male, with an average age of 52.7 years (range, 19-77 years). Right elbows represented 48.2% of all cases. Transosseous fixation was the most common type of fixation, with 58.9% of patients undergoing this construct and 41.1% of patients undergoing suture anchor repair. The average duration of follow-up was 4.3 years (range, 1.2-10.5 years). No differences in age or distribution of side of repair were identified between fixation groups ($P > .05$; Table II).

Table I Demographic information of the patients

Age (y)	52.7	SD: ±12
	No.	%
Operative side		
Right	27	48.20
Left	29	51.80
Operative construct		
Transosseous	33	58.90
Suture anchor	23	41.10

SD, standard deviation.

Table II Demographic factors of each construct group

	Transosseous	Suture anchor	*P* value
Age (y)	51.1 ± 12.8	54.9 ± 10.6	.25
Operative side			
Right	16 (59.3%)	11 (40.7%)	.96
Left	17 (58.6%)	12 (41.4%)	

The average postoperative MEPS of the entire cohort was 94 ± 9.5 (Table III, Fig. 1). The transosseous group averaged a score of 92.8 (95% confidence interval [CI], 89.0-96.8), and the suture anchor group performed similarly with an average score of 95.6 (95% CI, 92.3-98.6). There was no difference in MEPS outcomes based on construct type ($P = .25$).

The average postoperative DASH score of the entire cohort was 4.8 ± 5. A statistically significant difference was found, with the transosseous group averaging 3 points lower (95% CI, –5.61 to –0.24; $P = .03$) compared with the suture anchor group (Table III, Fig. 2). However, this difference was not found to be clinically relevant as the minimally important clinical difference for the DASH score has been reported to be about 10 points.[6] Finally, postoperative VAS pain scores were found to be equivalent between groups as well ($P = .6$; Table III).

In general, patients were very satisfied with their operation. Patients stated they were satisfied with their operation in 53 (94.6%) cases and stated they would have the operation done again in 54 (96.4%) cases. Only 1 patient in the transosseous group and 2 patients in the suture anchor group stated they were not satisfied. Overall, patients were equally likely to report satisfaction with their surgery regardless of fixation construct (relative risk [RR], 1.01; 95% CI, 0.91-1.13; $P = .56$). Similarly, both groups had only 1 patient who would not be willing to undergo surgery again, with equal likelihood of reporting willingness to participate again (RR, 1.04; 95% CI, 0.38-2.88; $P > .99$).

Only 4 patients (7.1%) experienced rerupture of the triceps requiring revision surgery, with 2 patients in the transosseous group and 2 patients in the suture anchor group experiencing

Table III Outcomes based on surgical fixation

	Transosseous	Suture anchor	Absolute difference or relative risk (*RR*)	*P* value
MEPS	92.8 (95% CI: 89.0-96.8)	95.6 (95% CI: 92.3-98.6)	2.8 (95% CI: −7.5 to 2.0)	.25
DASH	3.59 (95% CI: 2.02-5.15)	6.57 (95% CI: 4.25-8.89)	2.98 (95% CI: −5.61 to −0.24)	.03
VAS pain	0.55 (95% CI: 0.23-0.87)	0.71 (95% CI: 0.14-1.27)	0.15 (95% CI: −0.75 to 0.43)	.6
Rerupture?	2 (6.1%)	2 (8.7%)	RR = 0.68 (95% CI: 0.09-5.2)	>.99
Satisfied (yes)?	32 (97%)	21 (91.3%)	RR = 1.01 (95% CI: 0.91-1.13)	.56
Do surgery over again (yes)?	32 (97%)	22 (95.7%)	RR = 1.04 (95% CI: 0.38-2.88)	>.99

MEPS, Mayo Elbow Performance Score; *DASH*, Disabilities of the Arm, Shoulder, and Hand; *VAS*, visual analog scale.

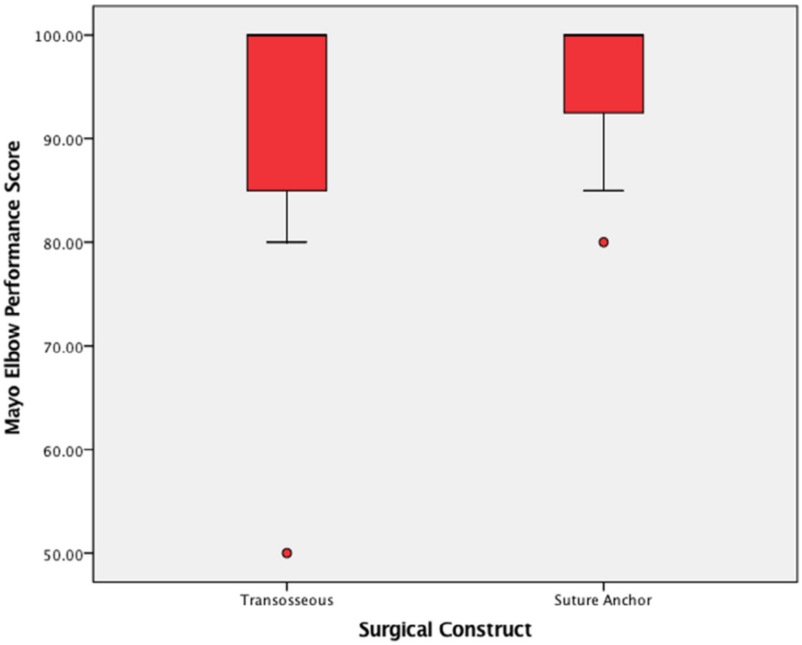

Figure 1 Mayo Elbow Performance Score based on surgical repair technique.

a rerupture. One of the transosseous patients had a traumatic injury that resulted in rerupture. The other 3 patients (1 transosseous repair and 2 suture anchor repairs) were found to have rerupture on MRI after complaining of continued pain or weakness after the initial surgery. Although the suture anchor group had a higher rate of rerupture (8.7% vs. 6.1%), there was no difference found in risk of rerupture based on fixation construct (RR, 1.23; 95% CI, 0.44-3.48; $P > .99$). All of the patients who sustained a rerupture of the tendon underwent revision repair with a construct similar to that performed during primary repair; the 2 patients with a failed transosseous repair had a revision bone tunnel repair, whereas the 2 patients with failed suture anchor repair were revised with new anchors. The mean time between primary repair and revision repair was 4.6 months (range, 2.5-6.2 months).

Discussion

The current series of patients undergoing triceps tendon repair did not find a significant difference in multiple outcome measures between those patients treated with transosseous tunnel repair and those treated with anchor repair. MEPS and VAS pain scores were nearly identical for both groups, and neither reached statistical significance in their marginal differences. These results are comparable to those reported in the literature for both the MEPS and the DASH.[3,9] Bava et al measured various clinical outcomes in distal triceps rupture patients treated with suture anchor repair and found patients to have excellent elbow function with an average MEPS of 95.8 and DASH score of 1.4.[3] The patients treated with anchor repair in our study demonstrated a nearly identical mean MEPS at 95.6 and a comparable DASH score of 6.6. Neumann et al reported a mean DASH score of 10.3 in a small series of patients after transosseous repair.[9] Kose et al reported a mean MEPS of 96.3 after transosseous repair in a series of 8 patients.[7] The average DASH score was 3.6 and MEPS was 92.8 for transosseous tunnel repairs in the current series, which is comparable to the previously reported results.[7,9]

Outcome studies comparing repair constructs for distal triceps injuries are overall lacking. van Riet et al published

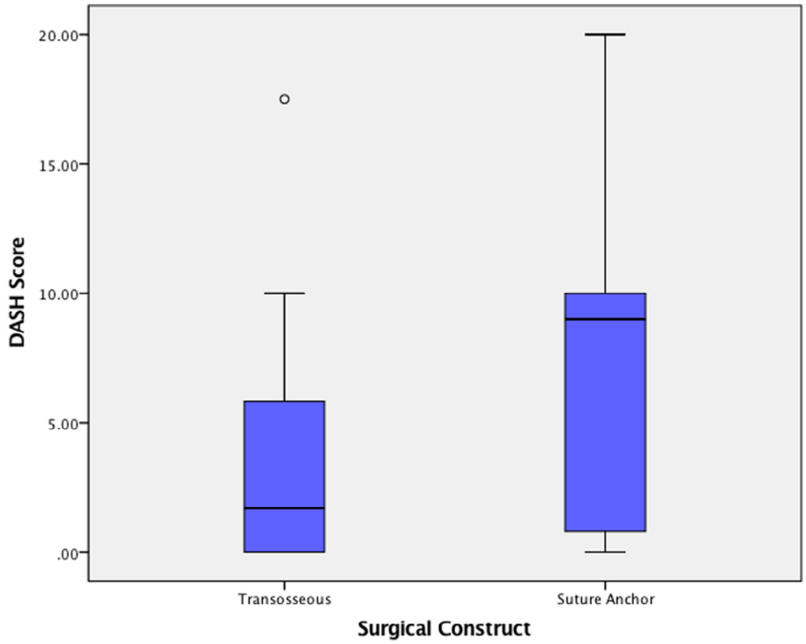

Figure 2 Disabilities of the Arm, Shoulder, and Hand (*DASH*) score based on surgical repair technique.

a series of 23 distal triceps repairs, with 14 of those repairs being primary without the use of any tissue grafting.[12] All of these repairs were performed with the use of transosseous tunnels only. Of those 14 repairs, all patients reported being satisfied or very satisfied with their outcomes. Patients averaged 92% of the peak strength of their contralateral upper extremity and had an average elbow range of motion arc of 8°-138° of flexion.[12] The authors concluded that when treated acutely (within 3 weeks), patients with distal triceps ruptures have good outcomes; these outcomes are much improved compared with those of patients with delayed diagnosis and subsequent reconstruction with allograft.[12] A larger study examining a military population of 48 triceps ruptures with a minimum of 1-year follow-up found that 94% were able to return to service after repair.[2] This study consisted of both transosseous and suture anchor repair constructs, but because of poor operative report records, the 2 groups were examined collectively and could not be directly compared.[2] Like these 2 prior studies, our series also supports good outcomes for primary triceps repair. In addition, the comparison of transosseous repair with suture anchors demonstrates that both are equally effective. This is something that has not been discerned before in the literature.

In our study, patients were repaired in 1 of 3 methods: transosseous tunnel repair, suture anchor repair, or hybrid suture anchor and transosseous repair. For comparison in our study, we grouped the suture anchor and hybrid repairs into the suture anchor group as the main strength of the repair came from the suture anchors. In 2010, Yeh et al performed a cadaveric study comparing the biomechanical strength of 3 different repair constructs: transosseous tunnel repair, single-row anchor repair, and transosseous-equivalent double-row anchor repair.[16] The authors found that the transosseous-equivalent repair best re-created the anatomic footprint of the triceps tendon insertion and resulted in the least amount of repair displacement after cyclical loading.[16] In terms of load to failure, the authors found that all 3 constructs had statistically similar yield and peak loads. Failures that occurred were seen at either the suture or suture-anchor interface, which led the authors to conclude that the type of repair had little to do with the cause of failure.[16] Another biomechanical study comparing transosseous repair with a knotless anchor repair also found that anchor repair demonstrated less displacement of the repair ($P < .05$) but also demonstrated greater yield and peak load ($P < .05$).[5] In our study, we experienced 2 failures in each of the repair groups. There was no statistically significant difference in the odds of failure between construct groups, and this coincides with Yeh et al in finding no significant difference in construct failure.

Four patients in our study, 2 patients from each construct group, had a failure of their primary repair. Overall, this accounted for a 7% failure rate for all repair types (6% of all transosseous repairs and 9% of all suture anchor repairs). This failure rate is lower than in previously published studies.[2,12] A 21% failure rate was demonstrated in the 14 transosseous repair patients examined in the study of van Riet et al.[12] Of the 3 reruptures in that study, only 1 was definitively caused by a traumatic injury. All 3 were repaired; 1 patient required reconstruction with the use of allograft because of delayed presentation, and another required 2 revisions because of a second rerupture.[12] The authors noted all 3 patients to have a good outcome. In the study by Balazs et al, all 6 reruptures were due to traumatic injury within 4 months of the initial repair.[2] Three of the reruptures were complete tears that required revision surgery, and this resulted in 1 patient's being discharged from active duty. Similarly, 1 of the partial tear patients treated with nonoperative management was also discharged from active duty.[2] Three of the 4 failures in our series had sustained a new injury that resulted in rerupture. All 4 patients who sustained a failure of repair were revised with a construct similar to their primary repair on revision.

The majority of patients in this study were satisfied with the outcome of their surgery. Both anchor-based repair and transosseous repair patients demonstrated >90% satisfaction rates, with 95% or more responding that they would have the respective repair again if necessary. Only 3 of the 4 patients who sustained rerupture were satisfied with their outcome and willing to undergo the procedure again. These results are comparable to those reported by van Riet et al, in which 13 of 13 patients were satisfied or very satisfied after primary repair despite 3 of 13 having a rerupture.[12] Again, the small number of reruptures in our cohort makes it difficult to conjecture about these results, and future investigation should focus specifically on outcomes of revision repair.

There were limitations to this study. First, it is a retrospective study, making the findings and conclusions susceptible to the biases that exist within retrospective series. Many of the patients had outcomes obtained through phone interviews only; therefore, physical examination measures were not able to be manually performed. Second, certain variables were unable to be compared between the 2 study groups. In particular, there was no cost analysis performed between the 2 groups. This would be of particular interest in the modern environment of decreasing the cost of an episode of care. We would hypothesize that the cost for anchor-based repair would be greater than that of transosseous repair, but further studies would be needed to conclude this. Moreover, measured, quantitative clinical strength testing would be of interest between groups. Extension strength testing was performed only with graded manual motor testing. In addition, advanced imaging, such as MRI or ultrasound examination of the tendon repair site, could have aided in establishing healing and rerupture rates more accurately. Given the very functional nature of extensor mechanism repair, however, we thought that physical examination was satisfactory to determine a successful repair. Only patients with symptoms concerning for rerupture underwent imaging studies to prove this. Last, there is some limitation in our analysis with the grouping of hybrid repairs into the anchor-based repair group. One could argue that these cases should have been analyzed as a separate group entirely. We thought that the anchor-bone interface in these repairs, however, provided the majority of the repair strength and decided to group them accordingly.

Conclusion

Our study demonstrates that acute repair of the distal triceps is highly successful regardless of the repair construct performed. Overall clinical success based on functional outcome scores of anchor or transosseous tunnel repair constructs is high, equivalent and comparable to prior published results. Complication rates are low with very low rerupture rates, lower than previously reported. Rerupture may reduce overall clinical satisfaction and willingness to undergo surgery again, although it does not appear to reduce final functional outcome if revision repair is successful. Consequently, the clinical decision to use an anchor or transosseous tunnel repair should be based on the surgeon's preference because technique does not appear to have a significant effect on final outcome. Future studies should focus on risk factors for rerupture as well as cost analysis comparing anchor and nonanchor repairs.

Disclaimer

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