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The distal triceps tendon insertional anatomy—implications for surgery

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Background: Improved knowledge of the distal triceps insertion is needed as a result of an increase in procedures involving this area, including distal triceps repair, posterior capsulectomy, and olecranon tip osteotomy for coronoid reconstruction.
Materials and methods: Five pair-matched upper limbs were dissected to study the morphology and dimension of the distal triceps tendon, triceps tendon insertion, capsular insertion on the olecranon, and triceps lateral retinaculum. Muscle origins of the triceps insertions were identified proximally.
Results: Three distinct insertional areas were found in the olecranon corresponding to the posterior capsular insertion, the deep muscular portion, and the superficial tendinous portion of the triceps with areas of 1.5, 1.2, and 2.8 cm^2, respectively. The deep muscular head corresponded to the medial head of the triceps and the tendinous portion corresponded to the long and lateral heads and correlated with the height of the specimen. The triceps width at insertion was 2.6 ± 0.5 cm (standard deviation), and the triceps lateral retinaculum extended the tendon laterally for 2.5 ± 0.7 cm. The tendinous portion of the triceps tendon extended proximally 15.3 ± 1.4 cm. The triceps inserted at a mean of 1.1 cm from the tip of the olecranon.
Conclusions: The distinct insertional heads of the triceps provides additional knowledge that can aid in diagnosing and treating partial triceps tears. In addition, a safe zone for capsulectomy and olecranon tip osteotomy is described that can be used to increase the safety of these procedures.

The triceps has historically been described as consisting of 3 muscular heads—the long head, the lateral head, and the medial head—that coalesce into a common and single insertion on the olecranon. The radial nerve innervates all 3 heads, but they originate from different anatomic sites at the glenoid and posterior aspect of the humeral shaft and are thought to insert at a distinct common insertion site.

Some authors have reported an isolated avulsion of the medial head of the triceps, but other anatomic studies have failed to find a distinct insertion pattern.[2,10,12] The morphology of the injury may affect clinical presentation, imaging analysis, and surgical strategies. Furthermore, complications with triceps healing after total elbow arthroplasty have generated renewed interest in the adoption of "triceps-on" exposures and lateral and medial paraolecranon approaches that respect portions of the triceps insertion.[1,5,16,17]

There are several clinical scenarios in which an exact knowledge of the insertional anatomy of the triceps to the olecranon might aid surgical treatment. Traumatic injuries to the triceps tendon, although relatively rare, require prompt diagnosis and oftentimes surgery. They are generally associated with a sudden event resulting in an eccentric load to a contracting triceps, usually with the arm in extension. It is uncommon that the whole triceps insertion is avulsed, and the lateral part of the tendinous insertion is typically left intact, which can delay diagnosis, but the recent recognition of the occurrence of partial tears requires additional anatomic knowledge.[11]

Apart from triceps tendon injuries, the propensity for surgical intervention involving the posterior aspect of the elbow, including exposures for distal humeral fracture internal fixation, elbow arthroplasty, and the use of portions of the olecranon as a graft for patients with persistent elbow instability, has fostered an interest in the anatomy of the distal tendon triceps tendon and its insertional footprint.[1,4,7,13,15,19] Recognition of a distinct footprint area would be of value in the diagnosis and repair of acute triceps ruptures, in designing effective surgical strategies for exposure to the elbow, and avoiding injury when performing operations involving the posterior olecranon.

A specific proposal from the Biospecimens Committee for this study was approved by the Mayo Clinic Institutional Review Board (10429.006).

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The purpose of this study was to perform an anatomic study of the triceps insertion and its relationships to the 3 muscular origins with a special focus on the insertional footprint in the olecranon. We hypothesized that different portions of the triceps would have specific insertional footprint areas.

Materials and methods

Five paired-matched cadaveric upper limbs (total 10 limbs) including the shoulder, arm, elbow, forearm, wrist, and hand were obtained from the Mayo Clinic Institutional Department of Anatomy. Origins of the muscles were included to trace the relative contributions to the insertional footprint. No specimens had evidence of prior surgery or obvious injury to the elbow joint. The deceased donors (3 men and 2 women) were a mean (standard deviation) age of 72.4 ± 11.86 years (range, 56-86 years), a mean height of 169.3 ± 13.6 cm, and had a mean body mass index of 24.38 ± 2.39 kg/m^2.

The specimens were thawed at room temperature 24 hours before dissection, which was done using a midline posterior skin incision exposing the brachial and antebrachial fascia with the elbow in 90° of flexion. The superficial fascia was removed to expose the triceps muscle and tendon while protecting the ulnar nerve that had been previously isolated.

The triceps proximal muscular origins were isolated and followed distally. Gross measurements of the triceps tendinous portion and the lateral retinaculum to its insertion were performed. The triceps muscle was divided just proximal to the most proximal part of the superficial tendon and dissected distally toward the insertion separating it from the medial and lateral septum and the posterior aspect of the humerus. Laterally, the triceps was dissected from the brachioradialis and wrist extensors to facilitate exposure of the deep side of the triceps muscle and tendon along with the fat pad and capsule. The lateral side of the tendon was identified from the deep portion of the triceps, as the fibers were seen inserting into the olecranon and separate from the lateral retinaculum. The distal insertion of the retinaculum into the forearm fascia and the lateral extension of the retinaculum at the level of the triceps insertion were also measured.

The width of the triceps tendon was measured at the insertion and at 3 and 6 cm proximally. The capsule was released from the deep portion of the tendon and was released from proximal to distal to reveal its insertion on the olecranon. After the capsule was completely released, an attempt to distinguish discrete deep and superficial layers of the tendon at the insertion was performed. Finally, progressive release of the tendon insertion was performed, and footprint measurements were recorded. The footprint area was calculated using the methodology described by Yeh et al.[20]

All measurements were performed using a digital sliding caliper with precision to 0.1 mm (SE 784EC; Electronix Express, Rahway, NJ, USA) and were taken twice by a single surgeon with an interval of approximately 1 hour. The mean ± standard deviation (range) of these measurements was recorded. This was not possible for some measurements that required excision of the structure. Descriptive statistical analysis was performed with IBM SPSS Statistics for Windows 20.0 software (IBM, Armonk, NY, USA). Statistical significance was defined as the likelihood of differences to have occurred by chance to be <.05.

Results

Triceps muscle dissection

The triceps tendon had a distinct medial border extending proximally further than the lateral side, with the tendinous portion having a pennate aspect at mean distance from the olecranon of 15.25 ± 1.4 cm (range, 13.5-17.7 cm; Fig. S1). The superficial fascia of the triceps tendon had a direct relationship medially with the ulnar nerve and had fibers that extended into the posteromedial gutter, contributing to the floor of the ulnar nerve.

The tendinous portion extended laterally past the lateral border of the olecranon for a mean of 3 ± 0.7 mm (range, 1.5-3.8 mm; Table I). On visual inspection, delineating a discrete borderline between the lateral border of the triceps tendon and the lateral retinaculum was difficult. The dimensions of the triceps tendon were considered to include those fibers that connected to the olecranon on the deep side of the insertion, but this distinction was hard to make on the superficial side, especially on the lateral side of the tendon, which was hard to distinguish from the lateral retinaculum. Distally, the fibers of the lateral retinaculum blended with fibers of the forearm fascia covering the anconeus muscle and inserting into the ulna, with the most distal fibers at a mean distance of 8 ± 0.8 cm (range, 7-9 cm; Fig. S2). With extension of the elbow, these divergent fibers aligned with the rest of the triceps extensor mechanism. Morphologic aspects of the lateral retinaculum are reported as Supplementary Material.

The triceps tendon and lateral retinaculum were dissected laterally in the interval between the brachioradialis and the triceps, elevating the muscle from the posterior aspect of the humerus and lateral column until the capsule was seen. The ulnar nerve was dissected free from the superficial fascia on the medial side, and the medial head of the triceps was elevated from the posterior aspect of the humerus and the medial intermuscular septum until the capsule was seen. The triceps muscle was divided at the level of the musculotendinous junction and flipped forward to continue the dissection of the capsule and the overlying muscle.

Table I
Measurements of the triceps length and lateral retinaculum dimensions*

Specimen	Triceps length	Triceps width			Lateral retinaculum		
		At insertion	At 3 cm†	At 6 cm†	Proximal expansion	Width	Length
1	149.37	39.92	37.22	35.48	35.65	16.44	76.92
2	151	26.36	36.02	35.37	34.3	15.28	74.98
3	151.28	27.72	32.39	36	46.71	27.16	83.45
4	174.1	27	32.93	37.22	38.33	29.08	88.24
5	143.6	19.9	27.3	36.34	42.44	24.74	70.7
6	154.14	21.33	31.44	40.68	38.59	22.28	70.1
7	134.3	23.62	35.27	43.89	43.91	25.86	83.8
8	134.83	24.42	37.29	38.46	44.62	19.46	70.59
9	155.31	23.04	41.12	46.04	45.05	35.68	88.39
10	176.78	25.65	31.03	43.82	49.89	37.56	89.16

* See Fig. 2. All measurements are in mm.
† Measurements of the triceps width, 3 and 6 cm proximal to the tip of the olecranon.

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