

Morphology of the Cubital Tunnel: An Anatomical and Biomechanical Study with Implications for Treatment of Ulnar Nerve Compression

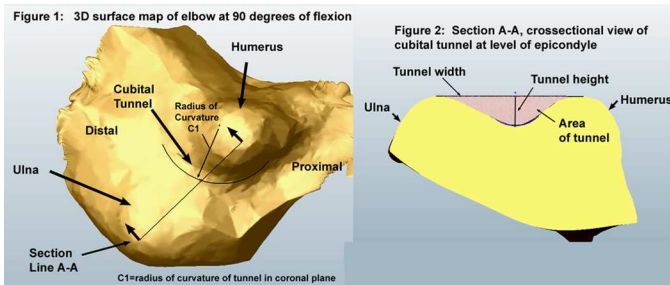
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HYPOTHESIS: Optimal management of the ulnar nerve at the elbow requires a thorough understanding of the anatomy of the cubital tunnel. The anatomical structures comprising the cubital tunnel dynamically change with elbow motion. The hypotheses of this study are 1) that the nerve elongates with elbow flexion and 2) that the cross-sectional area of the cubital tunnel is inversely proportional to the degree of elbow flexion.

METHODS: Eleven fresh frozen cadaver arms were anatomically dissected at the medial elbow. Anatomical variations were noted appropriately. The cubital tunnel retinaculum (CuTR) was identified and thickness measured at the time of dissection at 2 locations (1mm and 10mm from the tunnel entrance) using a caliper. This measurement was repeated afterwards at 4 locations on the CuTR, using a dial indicator on a granite table. The CuTR was excised and the ulnar nerve was indentified. The elongation of the anterior and posterior aspects of the ulnar nerve as well as the length of the CuTR origin/insertion was measured at increasing intervals of elbow flexion (15°, 30°, 45°, 90°, 120°, 135°) using 3D digitization technology. These elongations were converted to a percent increase in the nerve length, relative to the length at 15 degrees of elbow flexion. The ulnar nerve cross-sectional area was measured at 3 locations at the elbow by sectioning the nerve, photographing the section, and measuring the image area using Image J software. Using 3D digitization technology, the surface of the cubital tunnel was recorded at 4 positions of elbow flexion (15°, 45°, 90° (fig 1), 135°) and analyzed to define the tunnel geometry (width, height, area, curvature, fig 2). Statistical changes were analyzed using repeated measures ANOVAs at p<.05.

cross-sectional area of the ulnar nerve was an average 4.4mm² (1.4) when measured distal to the epicondyle, 5.1mm² (1.7) at the level of the epicondyle, and 4.1mm² (1.3) when measured proximal to the epicondyle. There was no statistical difference between these areas (p=0.42 or greater). The cubital tunnel area was statistically less at 135° compared to either 45° or 90° of flexion. The tunnel area was also statistically less at 15° compared to 90°. So, although there were differences in the tunnel area with flexion, there was not an inverse linear relationship between the two, thus not supporting our second hypothesis.

DISCUSSION: The roof of the cubital tunnel (CuTR) appears to stretch with increasing elbow flexion, suggesting that it becomes progressively more taut. An endoscopic, percutaneous, or other minimally invasive release of the CuTR would be facilitated with a taut posture. In addition to other factors, the inherent shape of the cubital tunnel may contribute to a predisposition for ulnar nerve entrapment/subluxation. Although this could not be demonstrated statistically in this study, two broad categories of cubital tunnel shape were observed; shallow and deep. Further study may demonstrate an at-risk population based on inherent cubital tunnel shape. Finally, the elongation data suggests the optimal position for post operative management or conservative care of the ulnar nerve at the elbow is between 30-45° of flexion when the nerve is less taut. As with any treatment regimen combining immobilization at the elbow, early range of motion should be emphasized.



Elbow flexion angle (deg)	CuTR origin to insertion length (mm)	Cubital Tunnel Geometry (std dev)			
		Height (mm)	Width (mm)	Tunnel Area (mm ²)	Coronal Radius of Curvature, C1 (mm)
15	24.4 (6.7) *	7.8 (1.4)	26.3 (3.6)	95.2 (23.2)	45.2 (62.6)
30	25.1 (5.9) **	#	#	#	#
45	26.5 (4.4) ***	8.7 (1.4)	29.5 (3.2)	111.2 (27.2)	20.3 (8.2)
60	29.2 (6.1)	#	#	#	#
90	32.5 (3.5)	7.0 (1.2)	33.6 (2.5)	112.1 (25.2)	16.0 (2.4)
120	35.0 (5.0)	#	#	#	#
135	36.1 (5.0)	3.9 (1.4)	31.4 (4.5)	61.9 (19.2)	12.1 (3.4)

* different from lengths at 60, 90, 120 and 135 degrees
 ** different from lengths at 60, 90, 120 and 135 degrees
 *** different from lengths at 90, 120, and 135 degrees
 # not measured at these angles

RESULTS: With regards to anatomical variants, one absent CuTR and dislocated ulnar nerve, one ulnar nerve subluxation, and one anconeus epitrochlearis was encountered on separate specimens. A range of 1 to 3 medial antebrachial cutaneous nerve branches were identified. There was no statistical difference between the retinaculum thickness measurements either at the time of dissection (mean 0.14mm (0.07), p=0.77) or afterward (mean 0.23mm (0.21), p=0.50 or greater) due to the large variations in thickness between samples and within a CuTR. The CuTR origin to insertion length statistically increased with increasing flexion angle (Table 1). There was an increase in the nerve length with increasing elbow flexion (fig 3). Statistically, the lengths at 90°, 120°, and 135° of elbow flexion were greater than at 15° or 30°. This was true for the elongation of the nerve and for the percent increase in length for the anterior aspect of the nerve. For the posterior aspect of the nerve, the lengths at 60°, 90°, 120°, and 135° of flexion were greater than at 15° or 30°. The elongation at 45° was less than at 90°, 120°, or 135°. This was true for the percent increase in length as well. This supports our first hypothesis. There was no difference in the percent increase in the nerve length for measurements made proximal or distal to the epicondyle (p<.832) and there was no difference for measurements made anterior or posterior in the canal (p<.066). A linear relationship between decreasing cubital tunnel height and increasing flexion angle was found (r²=0.66). At 90° of elbow flexion, for the 11 arms, there was a) a trend between increasing tunnel height and measured nerve cross-sectional area (r²=0.52) and b) a trend between increasing nerve cross-sectional area and an increase in the length of the CuTR origin to insertion length (r²=0.53). The

Figure 3: Percent Increase in Length of Posterior Aspect of Cubital Nerve (distal location = 3 cm distal to epicondyle; proximal location = 5 cm proximal to epicondyle)

