Introduction: The carpal tunnel is bounded radially, ulnarly, and dorsally by the carpal bones and volarly by the flexor retinaculum. The narrowest point of the carpal tunnel had previously been identified as at the level of the hook of the hamate [1], but this has been called into question in more recent studies [2]. These inconsistencies arise from two problems with using MRI for determining carpal tunnel dimensions. The first problem is that a cross-sectional area measured non-perpendicular to the axis of a cylinder will give a larger value, known as parallax error. Since it is difficult to predict the carpal tunnel axis by external measures, cross-sectional areas by MRI are inaccurate. Second, the soft-tissue borders of the carpal tunnel are not easily distinguished by MRI, and must be user-defined, which is also inaccurate. The purpose of this study is to evaluate the morphology of the carpal tunnel using a silicone cast that eliminates the problems associated with MRI. Additionally, correlations will be made between hand and carpal tunnel dimensions.

Materials and Methods: The hand dimensions of ten cadaveric specimens were first measured: wrist width, depth, and circumference at the distal wrist crease; palm width, depth, and circumference at the metacarpal heads; hand length from the tip of the long finger to the distal wrist crease; and hand volume. The specimens were then positioned in a custom apparatus and silicone was poured into the carpal tunnel. The silicone was then allowed to cure, creating a cast of the carpal tunnel. Several anatomical landmarks were then digitized, including the scaphoid, pisiform, trapezium, the hook of the hamate, and the proximal and distal edges of the transverse carpal ligament. The cast was then removed from the carpal tunnel, affixed to the apparatus, and the entire surface digitized. The digitized data were then reconstructed using the anatomical landmarks as reference points. The central axis of the carpal tunnel was then determined and the dimensions of the carpal tunnel calculated including width, depth, tilt angle (Figure 1), cross-sectional area, and volume. The length of the carpal tunnel is defined between the most distal point at the proximal edge of the transverse carpal ligament and the most proximal point at the distal edge of the transverse carpal ligament. Since the cross-section of carpal tunnel is approximately an ellipse, the long axis was defined as the width and the short axis was defined as the depth. The tilt angle was defined as the angle between the long axis and the projection of a line passing through the trapezium and the hamate to the cross-section. These dimensions were calculated at 10% intervals along the length of the carpal tunnel. These values were then analyzed by one-way repeated measures ANOVA to evaluate for significant differences. Correlation and regression analyses were then performed between hand and carpal tunnel dimensions.

Results: The carpal tunnel was successfully reconstructed into a three-dimensional model (Figure 2). Width, depth, and cross-sectional area did not change significantly along the length of the carpal tunnel (p = 0.09, 0.836, and 0.475, respectively), but tilt-angle increased significantly (p < 0.001) with distal progression along the carpal tunnel. The width of the carpal tunnel was 19.2 ± 1.7 mm, the depth was 8.3 ± 0.9 mm, the length was 12.7 ± 2.5 mm, the cross-sectional area was 134.9 ± 23.6 mm², and volume of the carpal tunnel was 1737 ± 542 mm³. The tilt-angle increased from 8.2 ± 8.8 degrees at the proximal end to 16.2 ± 6.1 degrees at the distal end. The width of the palm strongly correlates with the width of the carpal tunnel (p < 0.01, r = 0.829). Using regression analysis, a formula was derived to estimate carpal tunnel width using the width of the palm measured at the metacarpal heads: WidthCT = 1.285 + 0.236*Widthpalm.

Discussion: The width, depth, and cross-sectional area of the carpal tunnel do not change significantly along its length. The tilt angle of the carpal tunnel increases (the long axis of the cross-sectional slice rotates away from the radial side of the hand) with distal progression along its length. Carpal tunnel width can be predicted by palm width using a linear model.

References:

Figure 1- Schematic representing the elliptic cross-sectional slice of the carpal tunnel and definition of measurement parameters.

Figure 2- Three-dimensional reconstruction of the carpal tunnel.