INTRODUCTION: Fractures of the distal radius are the most common fracture of both adults and children. Distal radius fractures frequently heal with residual displacement and angulation with cast treatment and often cause distal radioulnar joint dysfunction including pain, decreased rotation, weakness, and arthritis. In spite of the frequency of these injuries, the indications for surgical treatment remain poorly defined. There are no reported studies that have comprehensively evaluated the effect of both isolated and combined distal radial deformities on distal radioulnar joint function. The objective of this study was to develop an improved understanding of how varying degrees of isolated and combined distal radius fracture deformities, with and without TFCC injury, affect forearm rotation using an in-vitro cadaver-based model. Our hypotheses were (1) combined deformities of the distal radius would decrease forearm rotation more than isolated deformities; and (2) resection (i.e. rupture) of the TFCC would allow for improved motion.

MATERIALS AND METHODS: Experimental Testing Protocol: Eight fresh frozen upper extremities (77 ± 5 years, 5 female, 2 right) with a radial inclination of 23.3 degrees 23.3 degrees (± 2.8), radial tilt 11.5 (± 1.1) and ulnar variance 0.4 (± 0.5) were thawed, tendons of interest were isolated and the specimens were mounted in a forearm testing apparatus. The tendons were sutured to cables and attached to actuators whereby active forearm rotation was computer controlled. Active pronation and supination was achieved by displacement control of the pronator teres and biceps respectively. An electromagnetic tracker quantified the position of the radius relative to the ulna (Ascension Technologies, USA). An osteotomy was performed just proximal to the distal radioulnar joint, and a 3-degree of freedom modular implant designed to simulate distal radius fracture deformities was secured in place. This allowed for accurate adjustment of dorsal angulation (DA), dorsal translation (DT), and radial shortening (RS). The implant consisted of distal and proximal components that were rigidly affixed to the underlying bone.

RESULTS: The modular implant system was able to reproducibly simulate the distal radial deformities of interest in the experimental specimens. Repeatability trials for our experimental protocol resulted in 0.34 and 0.41% variation for kinematics of pronation and supination respectively amongst the 10 runs, while reproducibility yielded a 0.18 and 0.47% variation.

Single Deformities: Dorsal Angulation (DA): Increasing DA produced a significant reduction in forearm pronation when the TFCC was intact (p<0.002). The loss of pronation was not statistically different from the native position until the magnitude of DA reached 30 degrees. Once the TFCC was sectioned, the range of motion was restored to the pre-injured state. The magnitude of DA had no significant effect on forearm supination (p=0.1). Dorsal Translation (DT): Increasing DT of the distal radial fragment decreased forearm pronation (p=0.03). Pronation was significantly different from the native position at 10mm (p=0.04) with the TFCC intact. Sectioning of the TFCC restored the range of motion to that of the native wrist (p=0.05). Only 6 of 8 specimens were able to simulate a 10mm DT prior to TFCC sectioning due to the constraints of the soft tissues. There was no effect of dorsal translation on the range of forearm supination (p=0.2). Radial Shortening (RS): The radius could not be shortened greater than 5mm in any of the specimens until the TFCC was disrupted. This finding was significant using the chi-squared analysis (P<0.001). Although a statistically significant effect on forearm rotation was not noted (p=0.08) with radial shortening of 5mm, only half of the specimens could simulate 5mm of radial shortening prior to sectioning the TFCC. Following this simulated ligament injury of the distal radioulnar joint, all but one specimen could achieve up to 7.5mm shortening of the distal radius.

Combined Deformities: Dorsal Angulation and Dorsal Translation: An insignificant loss of forearm pronation was observed as the magnitude of combined fracture malposition increased for the intact TFCC (Figure 1A). Significant loss of pronation was not noted until 20 degrees of dorsal angulation combined with 10mm of dorsal translation (p=0.03), or 30 degrees of dorsal translation with 5mm (p=0.04) or 10mm (p=0.001) translation. As the magnitude of fragment angulation and translation increased, fewer specimens were able to achieve these extreme positions decreasing the available data. Sectioning the TFCC caused an increase in the amount of pronation achieved, also allowing more specimens to achieve more extreme malpositions. Dorsal Angulation and Radial Shortening: Isolated dorsal angulation of 30 degrees caused a significant reduction in forearm pronation with an intact TFCC, yet there was no effect on supination (Figure 1B). When dorsal angulation was combined with radial shortening, significant loss in pronation occurs at angulations less than 30 degrees. Dorsal angulation of 20 degrees with radial shortening of 2.5mm resulted in a significant loss of pronation (p=0.04).

REFERENCES:

Figure 1 A, B: Mean Pronation Achieved for Combined Simulated DA with (A) DT, and with (B) RS, Intact TFCC. Standard Deviation (+14.8-26.9) not Shown for Clarity.

DISCUSSION & CONCLUSION: Other investigators have studied distal radial deformities with mechanical devices or external fixators. Our findings are in agreement with the work of Kihara et al.1 who also reported that dorsal angulation greater than 30° significantly reduced the amount of forearm rotation. Bronstein et al.2 also confirmed that radial shortening less than 5mm had no effect on forearm rotation. In the current study, pronation was not significantly affected until dorsal angulation reached 30 degrees. Due to constraints of the soft tissues about the wrist, some fracture patterns could only be achieved concomitant with a TFCC rupture and, therefore, a major ligamentous injury of the DRUJ or fractures of the distal ulna or styloid should be suspected if such deformities are observed clinically. Based on our results, surgeons evaluating distal radial fractures and malunions should carefully assess not only dorsal angulation, but the concomitant presence of dorsal translation and radial shortening which collectively can increase the dysfunction of the distal radioulnar joint. Hence these cases should be considered when deciding between non-operative and operative management of these common injuries.