INTRODUCTION:
The purpose of this cadaver study was to evaluate the effect of triangular ligament tears on distal radio-ulnar joint instability by motion analysis. The amount of the distal radius displacement against the ulnar head was measured during passive wrist motion to simulate daily activities of the hands, and three clinical tests for the evaluation of distal radio-ulnar joint instability; ulnocarpal stress test (Nakamura 1997), piano-key test (Cooney 1998) and DRUJ ballottement test (King 1996), were performed. For each measurement, the effect of forearm rotation was also analyzed.

METHODS:
Eleven fresh-frozen human cadaveric upper extremities (5 male and 6 female; 9 left and 2 right arms; mean age 87 years). The humerus was fixed securely on a wooden jig by screws with the elbow at 90 degrees flexion, allowing free forearm rotation and wrist motion. The humeral-ulnar joint was also fixed securely. The volar capsule of the distal radio-ulnar joint was opened (phase 1) and the triangular ligament was first released at the ulnar fovea insertion (phase 2) and then released at the base of the ulnar styloid process (phase 3). Measurement of the distal radio-ulnar joint motion was performed sequentially from phase 1 (intact) to phase 3.

An electromagnetic tracking device (3SPACE Vermont) was used for the monitoring and measurement of DRUJ instability. Of the two sensors, one sensor was placed on the diaphysis of the ulna and the other was placed on the diaphysis of the radius. The ulnar fovea was then labeled as a point F and designated as the fixed point of the ulna in the neutral wrist position. Additionally, the ulnar fovea was also labeled as point F’ and was designated as a part of the radius. DRUJ Instability might shift the radius against the ulnar head and simultaneously shift point F’ away from point F. This divergence between the radius and the ulnar fovea was designated as the F’-F distance.

Passive wrist motion, consisting of flexion, extension, flexion with radial and ulnar deviation, and extension with radial and ulnar deviation, was applied manually by one examiner (T.M.) with the forearm at 90°, 60°, and 30° supination, neutral rotation, and 30°, 60°, and maximal pronation, respectively. The extent of manual passive motion of the wrist was determined as the end range by Kartenbone’s Grade III procedure (1999). Then the maximal F’-F distances were recorded during passive wrist motions for each forearm position. Similarly, during passive testing procedures using the three manual tests, the maximal F’-F distances were recorded for each test.

The tests were repeated sequentially three times at phase 1, phase 2, and phase 3 of surgical release. Using 11 specimens, Pearson’s correlation coefficient which indicates the accuracy of the examiner during these measurements in each forearm position was found to be 0.976. Values of the maximal F’-F distance obtained from each of the 7 forearm positions and the 3 manual tests were analyzed by one-way repeated measures of analysis of variance. Post hoc testing by Bonferroni multiple comparisons test was used to compare F’-F values for the 7 forearm positions and 3 manual tests. Student’s t-test was used to compare F’-F distances at phase 1, phase 2, and phase 3 for each forearm position. All statistical analyses were performed on SPSS for Windows ver. 11.5J. The alpha level was set at 0.05.

RESULTS:
F’-F distance during passive wrist motion
Overall, the F’-F distances during the forearm pronation tended to be larger than those during the forearm supination. In phase 1, the mean F’-F distances ranged from 2.9 mm to 3.3 mm (0.7 mm – 7.0 mm), and those in phase 2 ranged from 2.9 mm to 5.1 mm (0.8 mm – 9.3 mm). There were no statistically significant difference in the mean F’-F distances between phase 1 and phase 2 in any position, except during passive wrist motion with the forearm in maximal pronation. In phase 3, the mean F’-F distances ranged from 3.5 mm to 7.0 mm (1.1 mm – 14.7 mm). Statistically significant differences in the mean F’-F distances were observed between phase 1 and phase 3 in all positions, except during passive wrist motion with the forearm in 30 degrees of supination (p<0.05). F’-F distance during clinical tests
Overall, the mean F’-F distances during the ulno-carpal stress test and DRUJ ballottement test were larger than those during the piano-key test in phase 1, 2, and 3; however, these differences were not statistically significant except for that during the DRUJ ballottement test in phase 3 (P<0.05). In the ulno-carpal stress test and piano-key test, there was no inter-phase differences in the F’-F distance. However, during the DRUJ ballottement test, there was a statistically significant difference in F’-F distance between phase 1 and 3 (P<0.05) (Figure).

DISCUSSION:
Our examination demonstrated that in normal specimens the F’-F distance for passive motion of the wrist during various degrees of forearm rotation was around 3 to 4 mm (phase 1). Therefore, within these F’-F distances, the distal radio-ulnar joint was considered to be stable. Release of the triangular ligament at the ulnar fovea insertion alone did not cause any significant instability of the distal radio-ulnar joint (phase 2), but release of the ligament at the base of the ulnar styloid process caused significant instability (phase 3). In particular, passive wrist motion with forearm pronation could result in major instability.

In normal specimens, large differences were observed in the F’-F distances between during the ulno-carpal stress and DRUJ ballottement tests and during the piano-key test; however, the differences were not statistically significant. This suggests that the amount of displacement of the radius against ulna during the ulno-carpal stress test varies significantly, whereas that during the piano key sign test is relatively consistent.

Among the 3 clinical tests, no significant increase in F’-F distance was observed in phase 3 during the ulno-carpal stress test or piano-key test, whereas the distance measured during DRUJ ballottement test was statistically larger in phase 3 than in phase 1. It is important to realize that based on our experimental results among the 3 clinical tests, the DRUJ ballottement test alone demonstrated a statistically significant degree of accuracy in the evaluation of distal radio-ulnar joint instability caused by complete triangular ligament release.

REFERENCES: