Three-dimensional (3D) ulnar variance: actual ulnolunate distance is greater in pronation due to dorsal translation of the ulnar head

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INTRODUCTION

Ulnolunate distance (ULD) and Ulnar variance (UV)
• Ulnolunate distance (ULD) is the principal parameter of ulnar impaction syndrome, which is one of the major causes of ulnar-sided wrist pain.
• The ulnar abutment has been thought to be aggravated by forearm pronation because of the increase in ulnar variance (UV) during pronation.
• However, pronation does not aggravate ulnolunate impaction in every person.
• We hypothesized that in three-dimensional (3D) space, the ULD might be greater in pronation because the ulnar head is dorsally translated.

MATERIALS AND METHODS

• 21 patients’ thin-slice computed tomography (CT) images of wrists.
• All of the patients took the CT scan for the precise evaluation of UV.
• No patient had any history of fracture, surgery, or deformity in the upper extremity, and no patient had any complaint of limitation of forearm rotation.
• Mean age: 47 years (range, 28-72)
• 11 males and 10 females
• 7 right wrists and 4 left wrists.
• The CT scans were taken first with the forearm supinated and then with the forearm pronated.
• Measurements were taken with 3D reconstruction bone models using MIMICS & 3-Matic software (R20 & R12, Materialise, Leuven, Belgium).

RESULTS

Ulnocarpal distance
• Ulnolunate distance in supination (A) and pronation (B) was measured as the shortest distance between the ulnar head and the lunate in three-dimensional reconstructions of the wrist from thin-slice computed tomography. The shortest distance between two bones was obtained by part comparison analysis using MIMICS & 3-Matic software (R20 & R12, Materialise, Leuven, Belgium) (C).

Amount of forearm rotation from supination to pronation
• Three-dimensional reconstructions of the supinated wrist and the pronated wrist are superimposed so that the ulnae are in the same position. The amount of forearm rotation from supination to pronation was measured as the angle formed by the ulnar articular surface of the distal radius at both positions (FRA, forearm rotation angle).

Ulnar variance (UV) change from supination to pronation
• Three-dimensional reconstructions of the supinated wrist and the pronated wrist are superimposed so that the radii are in the same position (A). The distance between the most distal point of the ulnar head (other than the ulnar styloid process) in supination and that in pronation was measured (B).

CONCLUSION

• Our study demonstrated that ULD change during forearm rotation is determined by the amount of TUH rather than by UV change.
• This may suggest that TUH is a physiological mechanism that prevents ulnolunate impingement during pronation.
• Wrist biomechanics associated with forearm rotation should be rethought from the current viewpoint, and further studies including clinical aspects will be necessary in the future.

Amount of translation of the ulnar head (TUH)
• The center of the distal radioulnar articular surface of the ulnar head was determined using the least square circle fitting method (A). The distance between this center in supination (S) and that in pronation (P) was measured in superimposed three-dimensional reconstructions of the supinated wrist and the pronated wrist (B).

Ulnocarpal distance
• The ULD was greater in pronation in 15 cases and greater in supination in 6 cases. The mean ULD in pronation (2.1 mm) was significantly greater than that in supination (1.7 mm) (p = 0.009), and the mean ULD change from supination to pronation was 0.4 ± 0.6 mm. On the other hand, the mean UTD was significantly greater in supination (5.4 mm) than in pronation (4.2 mm) (p = 0.004). The mean STD also was greater in supination (7.4 mm) than in pronation (6.5 mm), although the difference was not statistically significant (p =0.368).

Ulnar variance and translation
• The mean amount of forearm rotation in our cases was 102° ± 22° while changing from supination to pronation. UV increased in 11 cases and decreased in 10 cases while changing from supination to pronation. The mean UV change while changing from supination to pronation was 0.03 ± 0.6 mm. The mean amount of TUH while changing from supination to pronation was 4.0 ± 2.2 mm.

Correlation between parameters
• Correlation analyses between ulnolunate distance (ULD) change and ulnar variance (UV) change, and between ULD change and the amount of translation of the ulnar head, while changing from supination to pronation. There was no significant correlation between the ULD change and the UV change. The ULD change had a significant positive linear relationship with the amount of translation of the ulnar head.

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