STABILITY CONTRIBUTIONS OF THE ULNAR INSERTIONS OF THE TFCC IN DYNAMIC INSTABILITY OF THE DRUJ

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Introduction: The triangular fibrocartilage complex (TFCC) stabilizes the radius to the ulna in conjunction with the forearm interosseous membrane and the proximal radioulnar joint. There are two insertions of the TFCC into the ulna, the fovea and the styloid of the ulna. Recent clinical and biomechanical studies suggest that the distal radioulnar joint (DRUJ) instability may be caused by injury at the ulnar origin of the TFCC (1-3). We studied the relative contribution of each ulnar TFCC insertion in dynamic instability of the DRUJ during pronation-supination after sequential cutting of the insertions, using a custom-made forearm simulator.

Materials and Methods: Ten intact wrists and forearms from ten fresh-frozen human cadavers with a mean age of 70 years were dissected, with the exception of the soft tissue around the wrist and elbow, and forearm interosseous membrane. Three pronators (pronator quadratus, pronator teres, flexor carpi ulnaris) and three supinators (supinator, biceps, extensor carpi ulnaris) were preserved with the appropriate line of action determined for each. The specimens were set on a custom forearm simulator, which demonstrated natural passive pronation-supination motion regulated by a PC controlled motor. Additional muscle loading was controlled by air actuators.

We simulated agonist muscle loading as a nearly active rotation and antagonist loading representing resistive motion, such as in the case of twisting a heavy doorknob. Load was applied to pronators from maximum supination to maximum pronation (pronating) demonstrating agonist pronation, and at supinators as agonist supination, and vice versa. The muscle load was determined by previous in vivo and in vitro torque studies. Intact data were sampled during whole range of rotation in each muscle loading condition respectively. Fovea and styloid insertion of the TFCC were sequentially cut. In order to clarify the contribution of each insertion of the TFCC into the ulna, the styloid insertion was cut first on 5 specimens; then the fovea was cut. On the other 6 specimens, the fovea was cut first, and the styloid second. Motion of the radius, ulna and III metacarpal was monitored by an electromagnetic tracking device (3Space Fastrak, Polhemus Inc., Colchester, VT). The relative translation of the radius with respect to the ulna was determined from the intersection angle between the axis of the radius (line through the styloid process to center of sigmoid notch of the radius) and center of rotation on the ulnar head (DRUJ instability index) (Fig 1). Abnormal translation of the radius relative to the ulna was represented as changes of this index after cutting each insertion of the TFCC from intact. Relative contribution of each insertion to the DRUJ stability was calculated from % angle changes. A positive value was set as palmar direction translation and a negative indicated dorsal translation of the radius.

Results: Seven specimens represented the positive DRUJ instability index in pronation and negative in supination, while three demonstrated positive index throughout rotation with or without muscle loading. Without muscle loading, the contribution of the fovea and styloid to the stability of the DRUJ was almost identical in the pronated and supinated position (Fig 2A). After agonist load was applied, the fovea insertion demonstrated more contribution to the stability of the DRUJ from neutral position to maximum pronation. In the supinated position, both insertions stabilized the DRUJ almost identically. With antagonist loading, the contribution of the fovea insertion was greater than styloid insertions from neutral to maximum pronation position (Fig 2B).

Discussion: Palmar translation of the radius was demonstrated in pronated position at the DRUJ, while both directional translation may occur in supination. Both insertions of the TFCC into the ulna affected the DRUJ stability equally in unloaded condition. After agonist muscle loading was applied, the fovea insertion is more important to stabilize the DRUJ from neutral position to maximum pronation. In supinated position, stabilizing effect of the styloid was almost identical to that of the fovea. With antagonist loading, data also demonstrated the fovea insertion has more stabilizing effect to the DRUJ in pronation. In supination, the fovea indicated slightly larger contribution for the DRUJ stability. Since the DRUJ is relatively unstable in pronation, the soft tissue restraint is more important to stabilize the DRUJ. As the forearm rotation axis passes through the fovea, it includes isometric fibers during rotation. Therefore, the fovea insertion was more effective in stabilizing the DRUJ for resistive motion in pronation. The styloid insertion of the TFCC attaches at a distance from the rotation center, therefore it may allow sudden displacement of the radius as the chunk-like motion in pronated position with muscle loading. Conversely, the DRUJ is more stable in supination possibly due to joint congruity; in this position, the stability contribution of soft tissue is small and equal.

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Fig 2 Stability contribution of the ulnar insertion of the TFCC.
A: unloaded condition; B: antagonist loading.

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<tr>
<th>Pronation-Supination Angle (deg.)</th>
<th>Stability Contribution (%)</th>
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<td>Fovea</td>
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