SCIENTIFIC ARTICLE

Length Changes in Scapholunate Interosseous Ligament With Resisted Wrist Radial and Ulnar Inclination

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Purpose To investigate the changes in length of the scapholunate interosseous ligament (SLIL) when the wrist is resisting horizontal lateral load and the forearm is in full pronation *in vivo*.

Methods We obtained computed tomography scans of the wrists of 6 volunteers in 3 situations: 0° position (0° extension and 0° ulnar inclination) and full forearm pronation without force, and in the same position but with resisted ulnar and radial deviation. Nine zones of 3 subregions of the SLIL were measured and analyzed with computer modeling.

Results Changes in length of the palmar SLIL with resisted ulnar deviation were significantly greater than those without an applied lateral load. In contrast, the changes in length of the dorsal SLIL with resisted radial deviation were statistically greater than those in the 0° position without loading. However, no significant differences in the changes in length of the proximal SLIL were found in any of 3 situations, except the dorsal zone with resisted radial deviation.

Conclusions Application of lateral load has an effect on the separation of the palmar and dorsal insertions of the SLIL. The palmar subregion of the SLIL was more highly strained with wrist-resisted ulnar deviation. Conversely, the dorsal subregion of the SLIL was under greater tension with wrist-resisted radial deviation.

Clinical relevance For patients undergoing nonsurgical treatment of SLIL tears, a sudden contraction of ulnar or radial deviation agonist muscles may be harmful and contribute to SL instability. *(J Hand Surg Am. 2017;■(■):1.e1-e7. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Scapholunate, isometric contraction, lateral load, against lateral resistance, *in vivo*.

Online Exclusive

THE SCAPHOLUNATE (SL) JOINT HAS 2 transverse intercarpal ligaments (palmar and dorsal) and a proximal fibrocartilaginous membrane, connecting the scaphoid and the lunate.[1–4] These 3 distinct portions have different material and anatomical properties and play different roles in stabilizing the SL joint.[5,6]

Several studies of wrist kinematics have shown that, during wrist flexion-extension,[7–9] radial-lunar deviation,[3,7,10,11] dart-thrower's motion,[7,12–14] and even forearm pronation-supination,[9] the scaphoid and lunate demonstrate minimal motion relative to each other, and elongation of the 3 distinct SL ligament components varies with wrist position. Tensile changes in the scapholunate interosseous ligament (SLIL), by applying axial load or stress, have also been studied. Lee et al[15] used magnetic resonance imaging (MRI) *in vivo* to investigate the strain changes in the SL ligament when axially loading the wrist in the neutral

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and extended positions. More recently, Scordino et al[16] compared the tensile force between the scaphoid and the lunate in 6 cadaveric wrists in 2 wrist-pushup positions. They found that the tensile force between the 2 bones with the wrist in the extended position is greater than in the fist-pushup position.

In daily life, the wrist may experience load in either ulnar or radial deviation. For instance, tightening a bottle cap is a clockwise twist, which is a maneuver of resisted ulnar deviation. In contrast, opening a bottle cap requires the opposite movement, which is resisted radial deviation. However, no information is available regarding wrist kinetics under lateral loading. We hypothesized that the 3 regions of the SLIL would behave differently in response to loading conditions simulating translational displacement of the bones.

Because little is known about the elongation of the SLIL with the wrist under lateral loading, the current study was designed to investigate changes in the length of the SLIL with the wrist resisting horizontal lateral load at full forearm pronation *in vivo*.

MATERIALS AND METHODS

Subjects

With approval from the institutional review board and after obtaining informed consent, we recruited 6 healthy adult volunteers for this study, from the workers in our hospital. These volunteers received monetary compensation for their participation. The sample size of 6 was based on previous similar studies.[15–17] Volunteers were excluded if they had a history of wrist trauma, systemic or chronic disease that might affect the soft tissues in the wrist, prior wrist surgery, osteoarthritis, or pain. The subjects included 3 men and 3 women with average age of 34 years (range, 24–40 years). All the participants wore protective lead covering the gonads and thyroid to minimize radiation exposure. We confirmed that there were no any structural abnormalities in the wrist with plain radiographs and on computed tomography (CT) scans.

Image acquisition

The right (dominant) wrist of each subject was scanned with a high-speed, 16-slice, spiral CT scanner (Somatom Sensation 16; Siemens Medical Solutions, Forchheim, Germany) 3 times. One scan was performed with the wrist in a 0° position (0° extension and 0° ulnar inclination) and full forearm pronation without force, with the shoulder extended to 90° and the elbow in full extension. The other 2 scans were performed in the same position but with resisted ulnar and resisted radial deviation. Force was applied to the ulnar side of neck of the fifth metacarpal using horizontal retraction with a rubber elastic band and asking the volunteer to actively ulnarly deviate the wrist to resist the applied force. This was considered resisted ulnar deviation (Fig. 1A,B). Force applied to the radial side of the neck of the second metacarpal from the opposite direction with active radial deviation was considered resisted radial deviation (Fig. 1C,D). The wrist was always kept in the 0° position using a custom-designed, nonmetallic supporting frame (Fig. 2), with the fist half-clenched and the third metacarpal aligned with the longitudinal axis of the radius and the forearm in full pronation. Isometric contraction resisted the applied force to maintain this static position. The applied force was about 20 N.[15] The CT images with 1.0-mm slices were acquired at a maximum of 120 kVp and 80 mA as the wrist was scanned from the distal radius to the proximal metacarpals.

Three-dimensional reconstruction of SL joints and modeling the attachments

We used data acquired from the CT scans to reconstruct 3-dimensional images with analytic software (Mimics 13.0; Materalise, Leuven, Belgium).

The SLIL consists of 3 distinct subregions: palmar, dorsal, and membranous, as they are defined by their known bone attachments,[1,2,4,18] and we marked the origins and insertions of these ligaments on the surfaces of the bone reconstructions.[7–9,15,17] Each point defining the surface of the scaphoid origin site was mapped to the closest point on the lunate insertion site. The straight line connecting the 2 points was considered a fiber of the SLIL.[7] Attachments of the 3 subregions spread broadly. In order to clarify 3-dimensional functional anatomy of the SLIL, each of the 3 subregions of the SLIL was further divided into 3 zones, resulting in a total of 9 simulation zones per subject. The 9 paths were modeled similar to the method described by Chen et al[9] (Fig. 3). There are distal, middle, and proximal zones of the palmar and dorsal subregions of the SLIL, and palmar, middle, and dorsal zones for the proximal subregion. The 18 insertion sites of these zones were marked on the corresponding articular surfaces of the lunate and scaphoid.[7–9,15] The points of the digitized bony surface of the 0° position were imported into software Geomagic Studio V 11.0 (GeoMagic, Durham, NC) for creating 3-dimensional surface models of all the positions from clouds of digitized points.

We measured the length for each zone as the straight line in the center of the attachment subregion