Scaphoid Tuberosity Motion is Least During a Dart Throw Motion

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HYPOTHESIS: Optimal treatment of scapholunate interosseous ligament (SLIL) tears and distal radius fractures should stabilize a tear or fracture site while still allowing wrist motion. Since previous studies (Crisco et al, Ishikawa et al, Werner et al) have shown that scaphoid motion is minimized during a dart throw motion as compared to wrist flexion-extension or radioulnar deviation, a dart throwing motion might reduce the ligament forces on a repair or fracture. However, the specific dart throw orientation that minimizes carpal motion varies between subjects. The hypothesis of this study is that motion of the scaphoid tuberosity is least during a dart throw motion and if clinically measured might serve as an indicator of an axis through which scaphoid motion is minimal.

METHODS: 28 cadaver wrists were cyclically moved through flexion-extension, radioulnar deviation and dart throw motions using a wrist joint motion simulator. Six additional wrists were moved through multiple dart throw orientations. Scaphoid kinematics were measured throughout each motion and used to create animated models of each wrist. The scaphoid tuberosity was located and its 3D movement throughout each motion and used to create animated models of each wrist. The scaphoid tuberosity was located and its 3D movement relative to a neutral starting position was computed (figure 1a). Its peak 3D excursion during each wrist motion and its distal-proximal, dorsal-volar and radioulnar components were computed. Changes in the length of the dorsal and volar components of the SLIL (figure 1b, 1c) were computed throughout each wrist motion. Differences were statistically analyzed using repeated measures ANOVAs.

RESULTS: The 3D excursion of the scaphoid tuberosity (table 1, figure 2) was statistically less during the dart throw motion than during either the flexion-extension motion (p=0.00) or the radioulnar deviation motion (p=0.00). Distal-proximal translation of the scaphoid tuberosity was statistically greater than either the radioulnar or dorsal-volar translations. There was a strong correlation (r² = 0.73) for the volar SLIL component, r² = 0.62 for the dorsal SLIL) between increasing scaphoid tuberosity motion and increasing SLIL length (figure 3) during the flexion-extension motion. During the radioulnar deviation motion there was a correlation (r² = 0.65 for the volar SLIL component, r² = 0.66 for the dorsal SLIL) between increasing scaphoid tuberosity motion and increasing SLIL length. In the six arms in which 9 different dart throw motions were examined, those dart motions during which the scaphoid moved least had the least total scaphoid tuberosity motion (figure 4). Of these dart motions, a dart throw motion oriented at 45 degrees had a trend (p=0.19) to have less tuberosity motion than one aligned with the radioulnar deviation plane.

DISCUSSION: The motion of the scaphoid tuberosity is least during a dart throw motion. A wrist motion with less tuberosity movement and therefore less scaphoid motion, will have less dorsal and volar SLIL elongation. This study supports the goal of clinically evaluating the motion of the scaphoid tuberosity to find the optimal dart throw orientation to minimize loading of a SLIL repair or a distal radius fracture and may influence physical therapy protocols after these injuries.

REFERENCES:

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Table 1: SLIL Length and Increase in Scaphoid Tuberosity Displacement at the Endpoint of Motion Relative to the Neutral Wrist Position (standard deviation)

<table>
<thead>
<tr>
<th>Wrist Position</th>
<th>Scaphoid Tuberosity Displacement (mm)</th>
<th>Dorsal SLIL Length (mm)</th>
<th>Volar SLIL Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion-Extension at Maximum Flexion</td>
<td>6.0 (2.7)</td>
<td>6.9 (2.6)</td>
<td>8.6 (2.6)</td>
</tr>
<tr>
<td>Radioulnar Deviation at Maximum Ulnar Deviation</td>
<td>7.9 (2.7)</td>
<td>6.1 (2.0)</td>
<td>8.2 (2.6)</td>
</tr>
<tr>
<td>Dart Throw Motion at Max Ulnar Flexion</td>
<td>2.8 (1.4)</td>
<td>6.6 (4.0)</td>
<td>8.2 (2.1)</td>
</tr>
</tbody>
</table>

Figure 2: Absolute Magnitude of 3D Scaphoid Tuberosity Motion During One Cycle of Flexion-Extension, Radioulnar Motion and Dart Throw Motions (Average of 28 Arms)

Figure 3: Scaphoid Tuberosity Movement from the Reference Position and Length of Dorsal and Volar Components of the SLIL as a Function of Wrist Flexion Angle (Average of 28 Arms During Flexion-Extension Motion)

Figure 4: Relative Motion of Scaphoid Tuberosity for the 6 arms undergoing 9 different dart motions. (Tuberosity Motion is Amplified Due to Using Ulnar Coordinate System instead of the Radial Coordinate System)