Journal of Hand Therapy 29 (2016) 175–182

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

JHT Read for Credit Article #410.
Special Issue: Wrist

Scaphoid tuberosity excursion is minimized during a dart-throwing motion: A biomechanical study

Frederick W. Werner MME [a,*], Levi G. Sutton MS [a], Niladri Basu MD [a], Walter H. Short MD [a], Hisao Moritomo MD, PhD [b], Hugo St-Amand MD [c]

[a] Department of Orthopedic Surgery, SUNY Upstate Medical University, Syracuse, NY, USA
[b] Department of Physical Therapy, Osaka Yukioka College of Health Science, Osaka, Japan
[c] Division of Plastic and Reconstructive Surgery, Centre de Santé et de Services Sociaux de Gatineau, Gatineau, QC, Canada

ARTICLE INFO

Article history:
Received 16 November 2015
Received in revised form
26 January 2016
Accepted 2 February 2016
Available online 19 February 2016

Keywords:
Dart-throwing motion
Scaphoid tuberosity
Rehabilitation after carpal injury
Scapholunate interosseous ligament injury

ABSTRACT

Purpose: The purpose of this study was to determine whether the excursion of the scaphoid tuberosity and therefore scaphoid motion is minimized during a dart-throwing motion.
Methods: Scaphoid tuberosity excursion was studied as an indicator of scaphoid motion in 29 cadaver wrists as they were moved through wrist flexion-extension, radioulnar deviation, and a dart-throwing motion.
Results: Study results demonstrate that excursion was significantly less during the dart-throwing motion than during either wrist flexion-extension or radioulnar deviation.
Conclusion: If the goal of early wrist motion after carpal ligament or distal radius injury and reconstruction is to minimize loading of the healing structures, a wrist motion in which scaphoid motion is minimal should reduce length changes in associated ligamentous structures. Therefore, during rehabilitation, if a patient uses a dart-throwing motion that minimizes his or her scaphoid tuberosity excursion, there should be minimal changes in ligament loading while still allowing wrist motion.
Study Design: Bench research, biomechanics, and cross-sectional.
Level of evidence: Not applicable. The study was laboratory based.

Introduction

Optimal postsurgical treatment of scapholunate interosseous ligament (SLIL) tears and distal radius fractures should stabilize a tear or fracture site while still allowing for early wrist motion. Most published studies discuss methods to detect, grade, or repair injuries[1,2] and do not emphasize rehabilitation methods. A rehabilitation method suggested by Moritomo et al[3] advocates that patients use a dart-throwing pattern of motion after surgery.

Previous studies[4-6] have shown that scaphoid motion is minimized during a dart-throwing motion as compared with wrist flexion-extension or radioulnar deviation. This would suggest that a dart-throwing type of motion might reduce the ligament forces on a repair or fracture while still allowing wrist motion. However, the patient-specific dart-throwing orientation that minimizes carpal motion varies between subjects.[6] The purpose of this study is to assess a method that might eventually help determine a patient-specific dart-throwing motion that minimizes scaphoid tuberosity excursion. A second purpose was to determine if there is an association between scaphoid tuberosity excursion and SLIL length changes during wrist motion.

The first hypothesis of this study is that excursion of the scaphoid tuberosity is minimized during a dart-throwing motion compared with a wrist flexion-extension or radioulnar deviation motion. The second hypothesis is that a specific orientation of a dart-throwing motion will reduce scaphoid tuberosity motion more than other orientations. In this study, it is assumed that a wrist motion with less tuberosity movement will have less scaphoid motion, with less associated dorsal and volar SLIL elongations, which, in turn, will reduce loading on a SLIL repair or a distal radius fracture. If excursion of the tuberosity is clinically measured by direct palpation, one could determine the dart-throwing motion orientation during which the tuberosity excursion is minimal. If a patient can be trained or guided to use this wrist motion, scaphoid motion would be reduced and thus presumably allow for early range of motion exercise of the wrist when minimal carpal motion and SLIL length change are desired.

Work performed at SUNY Upstate Medical University.
* Corresponding author. Department of Orthopedic Surgery, SUNY Upstate Medical University, 3214 Institute for Human Performance, 750 East Adams Street, Syracuse, NY 13210, USA. Tel.: +1-315-464-6468; fax: +1-315-464-6638.
E-mail address: wernerf@upstate.edu (F.W. Werner).

0894-1130/$ – see front matter © 2016 Hanley & Belfus, an imprint of Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jht.2016.02.006

Purpose of study

The purpose of this study was to determine whether the excursion of the scaphoid tuberosity is minimized during a dart-throwing motion.

Methods

Cadaver wrist motion

Analyses involved scaphoid and lunate kinematic data from 29 (average, 67.8 years; range, 29-98; 14 females and 15 males) cadaver wrists. Each wrist had been previously cyclically moved through flexion-extension, radioulnar deviation, and dart-throwing motions using a wrist joint motion simulator[7] while intact[6] and after various ligament sectioning sequences.[8-11] In this study, analyses included only the data from scaphoid and lunate motions while all ligaments that were intact were analyzed.

During the wrist flexion-extension motion, the wrist moved from 50 degrees of flexion to 30 degrees of extension and back to 50 degrees of flexion repetitively for 6 cycles. During the radioulnar deviation motion, the wrist moved from 20 degrees of ulnar deviation to 10 degrees of radial deviation and back to 20 degrees of ulnar deviation repetitively for 6 cycles. During the dart-throwing motion, the wrist moved from 30 degrees of extension and 10 degrees of radial deviation to 30 degrees of flexion and 10 degrees of ulnar deviation and back to extension and radial deviation repetitively for 6 times. The limits of 50 degrees of flexion, 20 degrees of ulnar deviation, and 10 degrees of radial deviation were selected based on previous testing that identified some wrist motion limitations at the end ranges of motion. Study requirements necessitated that all wrists achieve the same endpoints of motion. The limit of 30 degrees of extension was selected to prevent the lunate sensor post (described later) from hitting the dorsal rim of the radius.

Six of these wrists had also been moved using a wrist simulator through 9 different orientations of a dart-throwing motion while all

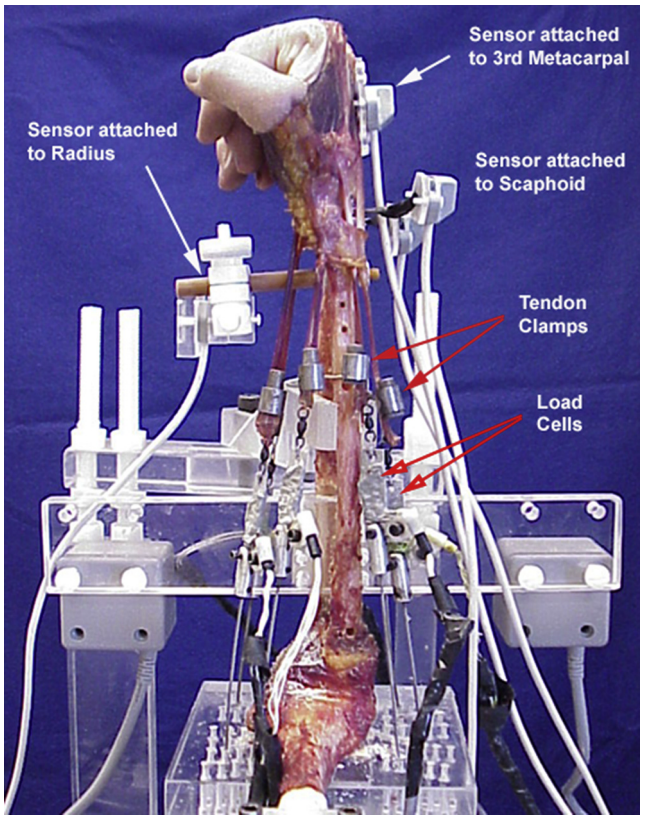

Fig. 2. Wrist joint motion simulator used to test each wrist. Motion of the third metacarpal and therefore the wrist was measured by an electromagnetic sensor mounted on the third metacarpal. Motion of the scaphoid (and lunate) was measured by sensors attached to posts cemented into each bone. These motions were referenced to the sensor mounted on the distal radius. Wrist motion was caused by actuators connected in series with clamps attached to the wrist flexors and extensors.

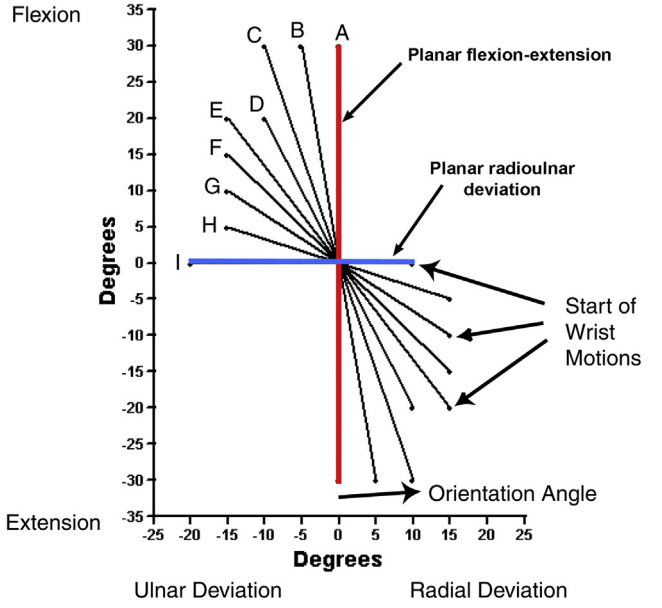

Fig. 1. Nine dart-throwing wrist motions studied as viewed in the transverse plane. Motion A is a pure extension-flexion motion. Motion I is a pure radial deviation to ulnar deviation. The other 7 motions were as the wrist moved from extension and radial deviation to flexion and ulnar deviation. The length of each line corresponds to the excursion of the motion. Reprinted with permission from Ref. 6.

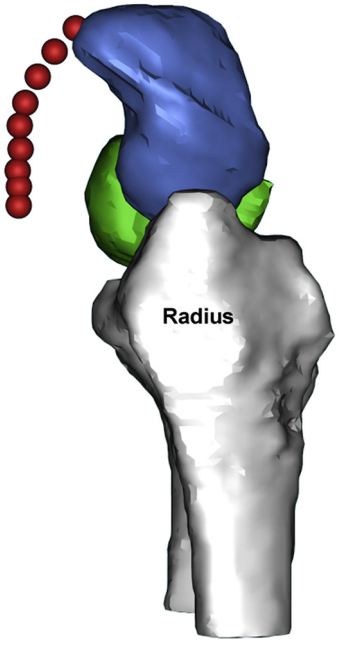

Fig. 3. Excursion of the scaphoid tuberosity movement during a flexion-extension motion is shown by a series of red spheres during the wrist motion. Scaphoid (blue) and lunate (green) are located with wrist in extension. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)