Does Thumb Immobilization Contribute to Scaphoid Fracture Stability?

J. Mark Schramm · Minhthy Nguyen ·
Montri D. Wongworawat · Ingrid Kjellin

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Abstract Immobilization protocols for nondisplaced scaphoid fractures have included the elbow, wrist, and thumb. This study attempts to demonstrate whether or not immobilization of the thumb makes a difference in preventing motion at the scaphoid fracture site. Using six fresh frozen forearm specimens, a transverse waist scaphoid fracture was created through a dorsal approach. Metallic markers were imbedded on either side of the fracture. Sutures were secured to the flexor pollicis longus (FPL) and extensor pollicis longus (EPL). Each specimen was loaded in extension and flexion by attaching 50-g weights to the EPL and FPL, first with no casting, then with a short arm cast, and finally a short arm thumb spica cast. Angulation and displacement at the fracture site were measured in the coronal, sagittal, and axial planes utilizing image reconstructions from computed tomography. One-way ANOVA with repeated measures and Tukey–Kramer multiple comparison test post hoc analysis were used for statistical evaluation. There was no significant

difference in fracture angulation or rotation between spica and short arm casts. There was a significant difference in angulation and rotation in all three planes when comparing between casting and no casting, $p < 0.05$. In our cadaveric model, wrist immobilization is crucial for nondisplaced scaphoid waist fractures, and short arm casting was just as effective as thumb spica casting in preventing fracture displacement.

Keywords Scaphoid · Fracture · Immobilization · Spica cast · Displacement

Introduction

The scaphoid is a commonly fractured carpal bone, accounting for up to 62% of all carpal fractures [14]. Injuries occur as a result of axial loading on a dorsiflexed wrist [17]. A wide range of treatment options is available for non-displaced and minimally displaced scaphoid fractures, including long arm thumb spica, long arm, short arm thumb spica, and short arm casts [4–6, 10, 11].

There is considerable disagreement in the appropriate casting protocol for scaphoid fractures. Authors have argued for the use of long arm thumb spica, short arm thumb spica, or short arm casts in their respective series of scaphoid fractures [4, 6, 11]. Additionally, many of the previous studies have used x-ray findings, which can have wide interrater reliability, to delineate fracture healing. This study is an attempt to more clearly define how scaphoid fractures behave in various casts [7]. By utilizing a CT scan to more clearly define fracture angulation and displacement and by loading the thumb in both flexion and extension, this study attempts to more precisely delineate the effects of various casting regimens on scaphoid fractures.

J. M. Schramm · M. D. Wongworawat (✉)
Department of Orthopaedic Surgery,
Loma Linda University Medical Center,
11406 Loma Linda Drive, Suite 218,
Loma Linda, CA, USA
e-mail: wwwortho@yahoo.com

M. Nguyen
School of Medicine, Loma Linda University,
Loma Linda, CA, USA

I. Kjellin
Department of Radiology,
Loma Linda University Medical Center,
11234 Anderson Street,
Loma Linda, CA, USA

Materials and Methods

Six fresh frozen cadaveric forearm specimens were obtained for the study. After a 24-h period of thawing, the scaphoid was identified through a dorsal approach using a #10 blade. A transverse waist scaphoid fracture was then produced using an osteotome. Metallic markers were placed on each side of the fracture. The extensor pollicis longus (EPL) and flexor pollicis longus (FPL) were then identified the proximal forearm, and a 0 Vicryl™ (Ethicon, Somerville, NJ, USA) suture was placed in a figure of eight pattern to the proximal end of each tendon.

The forearms were then placed in a support that held the arm in neutral rotation. Additionally, a pulley system was arranged to allow the application of weights to the suture attached to the EPL and FPL to simulate normal loading across the thumb interphalangeal joint. The wrists were imaged using the GE Lightspeed 16 detector CT scan with slice thickness 1.25 mm and scanned with the scaphoid at the center of the beam. The images were reconstructed at 0.5-mm intervals and reformatted in the coronal and sagittal planes.

The forearms were each used as their own controls. First, the forearm was scanned in a neutral position with no tendon loading and no cast immobilization. The EPL and FPL were then sequentially loaded with 50-g weights and scanned in the loaded position. This load was chosen to simulate physiologic loading based on Draganich's study of loading of thumb tendons [8]. This sequence was then repeated with the forearm in a short arm fiberglass cast

Figure 1 Sagittal reconstruction image with metallic markers on either side of scaphoid fracture.

Table 1 Results of angulation/rotation/translation based on immobilization type.

Parameter	No Cast	Short Arm Cast	Thumb Spica Cast
Angulation–Rotation (deg ± SD)			
Varus–Valgus	30.5±24.2 ^a	10.8±14.5	12.2±21.5
Flexion–Extension	32.7±20.0 ^a	9.0±6.7	5.2±4.8
Axial Rotation	19.8±12.0 ^a	3.3±2.3	2.7±2.3
Translation (mm ± SD)			
Anterior–Posterior	0.2±0.4	0.0±0.0	0.0±0.0
Medial–Lateral	0.3±0.8	0.0±0.0	0.0±0.0
Proximal–Distal	0.3±0.8	0.2±0.4	0.2±0.4

^a Significantly more angulation–rotation, $p < 0.05$

(immobilization up to the proximal portion of the thumb metacarpal and second through fifth metacarpal necks, but leaving the thumb metacarpophalangeal and interphalangeal joints free) and a spica fiberglass cast (immobilization including the thumb metacarpophalangeal joint).

The amount of motion across the fracture site was then quantified and compared within and across groups using one-way ANOVA with repeated measures and Tukey–Kramer multiple comparison test post hoc analysis. Specifically, the axial images were studied for the degree of rotation of the fracture fragments. The coronal images were examined for development of scaphoid varus/valgus deformity and medial/lateral translation of the fragments. The sagittal images were analyzed for amount of scaphoid flexion/extension deformity and for both anterior/posterior and axial translation (Fig. 1). An alpha value of 0.05 was selected for determination of significance.

Results

The results demonstrate that there is a significant difference ($p < 0.05$) between the nonimmobilized specimens and the immobilized specimens in rotation, varus/valgus, and flexion/extension of the fracture fragments (see Table 1). The type of cast, however, did not significantly differ in the amount of prevention of angulation of the scaphoid fragments. Gaping of the fracture, as measured by axial, anterior/posterior, and medial lateral translation, was not significant regardless of whether or not the fracture was immobilized.

Discussion

Several immobilization protocols are described in the literature, ranging from long arm thumb spica casting to short arm cast without thumb extension. The purpose of this study was to determine, using a cadaveric model, whether the wrist and/or the thumb need to be immobilized to decrease scaphoid waist fracture mobility.

Several assumptions were made for this study. Biomechanically, McAdams has demonstrated that pronation and supination of the forearm did not cause significant motion in scaphoid fracture fragments [13]. Cooney was able to achieve a 94% union rate in 45 consecutive scaphoid fractures immobilized with below-elbow casts [6]. Alho demonstrated equivalent fracture healing rates between above- and below-elbow casting in his prospective, randomized study of 100 scaphoid fractures [2]. In light of such previous research, we focused on casting below the elbow. The second assumption focused on imaging technique. Whereas previous studies have relied primarily on x-ray findings and snuff box tenderness to determine healing, this study utilizes CT to analyze fracture mobility [4, 11]. Dias, utilizing radiologists and orthopedists, found that the mean error in diagnosing a scaphoid fracture to be 40% [7]. He concluded that unless there was a clear lucent line, a distinct break, or step-off in the cortex, x-rays could not be relied upon for accurate diagnosis of scaphoid fracture. Adey, however, was able to demonstrate between 77 and 94% accuracy in detecting scaphoid fractures utilizing CT [1]. Given the increased accuracy of CT in detecting scaphoid fractures and assessing fracture deformity, we incorporated CT in our study to better visualize the scaphoid fracture mobility.

Immobilization of the wrist is crucial to limit fracture fragment mobility. Numerous studies to date have demonstrated that immobilizing the wrist is necessary to facilitate scaphoid fracture healing [2, 4, 6, 11, 12, 16]. Our results concur, noting a significant increase in fracture stability when immobilizing the wrist.

Conversely, whereas immobilization of the wrist is necessary to limit motion at the fracture site, casting the thumb is not. In his prospective study of 292 scaphoid fractures, Clay agreed that, though the wrist needed to be immobilized for fracture healing, the thumb interphalangeal joint did not [4]. He was able to achieve a 90% union rate with both the short arm cast and the thumb spica cast. Hambidge, in his study of 151 scaphoid fractures, was able to achieve 89% rate of osteosynthesis with wrist immobilization only [12]. Biomechanically, we demonstrated that, even in the presence of physiologic loading of the thumb, wrist immobilization alone was sufficient to significantly reduce motion at the fracture site.

Limitations of this study are an inclusion of only waist fractures and the ex vivo nature of the study. Healing rates vary significantly according to fracture location. It is well documented that proximal pole fractures require significantly longer time for osteosynthesis, secondary to the nature of the bone's retrograde vascularity [9, 11]. Distal pole fractures, however, heal more readily and rarely develop into nonunion [3, 14, 15]. An additional limitation is the type of fracture. Using an osteotome, we created a straight fracture line, unlike an in vivo fracture with fragment "keys" that could cause

increased friction between fragments. Future research could include both proximal and distal pole fractures to analyze the effects of short arm casting on these fractures. Also, we only tested EPL and FPL's effect on fracture fragment mobility. The limitations of this ex vivo study may be addressed further by dynamic studies to assess displacement with wrist and thumb motion in multiple planes, as well as assessing the effect of compressive loading during pinch grasp.

In conclusion, this study demonstrated that, for non-displaced scaphoid waist fractures, wrist immobilization is crucial to limiting fracture displacement. However, immobilization of the thumb metacarpophalangeal joint does not contribute to fracture stability under physiologic loading.

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