Computer-Assisted Navigation for Dorsal Percutaneous Scaphoid Screw Placement: A Cadaveric Study

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Purpose To investigate computer-assisted surgery (CAS) for dorsal insertion of percutaneous scaphoid screws and to compare operative time, accuracy, and fluoroscopy time with the traditional mini C-arm method. We hypothesized that CAS techniques would improve accuracy, reduce actual K-wire insertion time, and decrease fluoroscopy time.

Methods Ten fresh cadaveric upper limbs were randomized to either CAS or traditional dorsal percutaneous scaphoid screw placement by a single surgeon. Custom orthoses were applied to the CAS arms followed by intraoperative computed tomography (CT) scan and navigation calibration. Time was recorded for the portion of setup that required surgeon input, ideal guide wire placement, and fluoroscopy. Postoperative CT scans of the CAS arms were obtained to confirm accuracy. Two-tailed unpaired Student t test was used to analyze the outcome variables.

Results The CAS group required on average 4.8 $\pm$ 0.8 minutes longer for setup. The time for placement of the guidewire in the ideal position was 4.6 $\pm$ 1.5 minutes in the CAS group compared with 11.8 $\pm$ 4.4 minutes in the control group. Fluoroscopy time was 18 $\pm$ 4 seconds for the CAS group and 114 $\pm$ 38 seconds for the control group. Postoperative CT scans demonstrated 1.5 $\pm$ 0.6 mm maximum deviation from the planned ideal screw. No significant differences were found in the accuracy between methods, the number of guidewire attempts, or the total surgical time.

Conclusions Computer-assisted surgery navigation of dorsal percutaneous scaphoid screw placement takes on average 5 minutes longer to set up, but leads to significantly reduced guidewire placement time and no differences in overall procedural time. This CAS method was as accurate as the traditional method and resulted in an approximate 6-fold reduction in fluoroscopy time.

Clinical relevance This is an effective imaging alternative to the mini C-arm for scaphoid fixation using existing intraoperative CT scanners and navigation software. *(J Hand Surg Am. 2014;39(4):613–620. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Navigation, scaphoid, percutaneous.

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Scaphoid screw fixation is technically demanding because of the small size and complex anatomy of the scaphoid, and morbidity from inaccurate screw placement. Scaphoid screw fixation can prove challenging, and complication rates of 29% have been reported even in nondisplaced scaphoid waist fractures.[1] A suboptimal screw position can result in damage to articular cartilage, poor fracture stability, and significantly longer time to union.[2–4] Given these challenges to safe and accurate screw placement, some authors have begun to look to computer navigation for assistance.[5–7]

Advanced computer-assisted navigation is accurate and safe for all levels of vertebral pedicle screw placement[8–12] and pelvic screw fixation.[13] Evidence also suggests decreased operative time[14] and radiation exposure[11,12,15] with computer-assisted surgery (CAS). As a result, this technology is becoming available in some hospitals.

Computer navigation works by creating a virtual patient from a preoperative computed tomography (CT) scan. Special infrared-emitting diode trackers are then attached to the actual patient as well as to the surgical instruments, to allow the navigation system to calibrate and synchronize the virtual patient seen on the navigation monitor to the real patient. Thus, when a navigation instrument is moved in the virtual world, the same motion occurs relative to the actual patient. With navigation, simultaneous live views in the axial, coronal, and sagittal planes are provided to the surgeon to allow better visualization of complex 3-dimensional anatomy.

The delay in applying this technology to hand surgery largely results from difficulty in placing a sizeable tracker onto the small bones of the hand. To overcome this challenge, authors have successfully used various orthoses with and without traction.[5–7] In this study, we employed a custom thermoplastic orthosis to perform dorsal percutaneous scaphoid fixation using 3-dimensional computer navigation. This was a cadaveric study with a control group to quantitatively measure operative time and fluoroscopy time using 3-dimensional computer-assisted navigation for dorsal percutaneous scaphoid screw placement.

We hypothesized that computer-assisted navigation of dorsal percutaneous scaphoid screw placement would improve accuracy, reduce actual K-wire insertion time, and decrease fluoroscopy time.

MATERIALS AND METHODS

Ten fresh, nonfrozen cadaveric specimens sectioned at the midhumerus demonstrated no scaphoid fractures or fixed dorsal intercalated segmental instability on fluoroscopic evaluation. They were then randomized to either computer-assisted dorsal percutaneous scaphoid screw placement (Acutrak screw; Acumed LLC, Hillsboro, OR) or traditional dorsal percutaneous screw placement. A single orthopedic surgeon in an accredited hand fellowship performed all surgical procedures. The surgeon (CCK) had no prior computer navigation experience. For each procedure, the following times were measured: setup, ideal guidewire placement, and fluoroscopy. In addition, the number of K-wire attempts, the final screw position, and the number of perforations were evaluated.

Student unpaired 2-tailed *t* test was used to determine whether differences in outcome variables between computer-assisted and traditional techniques were significant; alpha was set to .05.

Surgical protocol for traditional dorsal percutaneous screw placement (control group)

The traditional dorsal percutaneous technique has been previously reported.[16] Each wrist was flexed and the forearm pronated, and the ideal starting point 1 to 2 mm radial to the membranous portion of the scapholunate ligament was identified with a 14-gauge needle. The needle served as a sharp trocar to guide the K-wire along the central path in the scaphoid. After fluoroscopic confirmation of the proper starting point at the apex of the scaphoid proximal pole, the wire was advanced 5 mm, aiming toward the palpable distal scaphoid tuberosity. A lateral fluoroscopic view was then obtained to check the proper dorsal and palmar trajectory to maintain central wire placement. Once the central wire trajectory was confirmed on multiple fluoroscopic views, the wire was advanced to the distal cortex. Final fluoroscopic images were obtained; if satisfactory, the clock was stopped and the time for ideal guidewire placement was noted.

The time measured up to this point was designated as that for K-wire placement. There was no setup time for the traditional technique. The number of K-wire attempts, defined as wires that reached the far cortex and then had to be removed, were recorded. Unacceptable guidewire position was any position outside the central third of the scaphoid. A 1-cm incision was made along the guidewire, and a hemostat was used to bluntly expose a track to the scaphoid base. The depth gauge was placed over the wire and directly onto the scaphoid. The length measured was subtracted by 4 mm to ensure against articular protrusion. The wire was then advanced and anchored into the trapezium before drilling. After drilling, the appropriate length headless compression