Orthopaedics & Traumatology: Surgery & Research 101 (2015) 353–357

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

Original article

# Intraoperative 3-dimensional imaging of scaphoid fracture reduction and fixation

S. Luria*, O. Safran, G. Zinger, R. Mosheiff, M. Liebergall

*Department of Orthopedic Surgery, Hadassah-Hebrew University Medical Center, Kiryat Hadassah, POB 12000, 91120 Jerusalem, Israel*

ARTICLE INFO

*Article history:*
Received 6 March 2014
Accepted 25 July 2014

*Keywords:*
Internal fixation
Intraoperative imaging
Scaphoid fracture
Wrist

ABSTRACT

*Introduction:* We examined the clinical benefit of two intraoperative three-dimensional imaging modalities for reduction and fixation of scaphoid fractures.
*Hypothesis:* Our hypothesis was that three dimensional imaging will aid in operative care in comparison with standard fluoroscopy.
*Methods:* In 25 consecutive patients treated for fractures, after satisfactory reduction and fixation was obtained with a single Kirschner wire using fluoroscopy, intraoperative three-dimensional visualization was performed. The quality of fracture reduction, wire position and extrusion of the wire were examined.
*Results:* In two of the 25 cases, after three-dimensional visualization, malreduction of the fracture was seen and the reduction revised. Artifact and the dependency on technologist performance, limited the use of these modalities to locate the wire accurately.
*Discussion:* Diagnosis of malreduction of a scaphoid fracture is possible with 3-dimensional modalities. Utilization of these systems is still limited by technical factors.
*Level of evidence:* Level IV. Retrospective study.

© 2015 Elsevier Masson SAS. All rights reserved.

## 1. Introduction

Reduction and fixation of scaphoid fractures are technically challenging and misplaced fixation screw is not uncommon [1–4]. In the operating suite, the fracture is reduced and fixed under fluoroscopic guidance. The desired fracture reduction as well as proper placement of the screw in the scaphoid is frequently difficult to assess using standard two-dimensional imaging techniques.

Computed tomography (CT) is the common method to evaluate the morphology of scaphoid fractures, and is the tool typically used for pre-operative planning. In addition, CT is commonly used to evaluate the postoperative results.

Previous studies reported the advantage of the use of intraoperative three-dimensional (3D) imaging during fracture fixation in orthopedic surgery [5–7]. Two possible modalities for this purpose were available for this study:

- the Siremobil ISO-C-3D$^{TM}$ (Siemens AG, Germany) which has a computerized image processing work station for intraoperative visualization;
- the C-InSight System (MAZOR Surgical Technologies, Israel) which is an add-on to the standard C-arm and includes an image adaptor connected to the C-arm and a sterile target which is placed on top of the imaged body part. The continuous images taken are analyzed by C-InSight software producing 3D reconstructions of the images taken.

In a report composed mainly of calcaneal fractures and intra-articular fractures of the knee and hip joints, revision of reduction or fixation was reported in 11% of cases [5]. Revision was due to unacceptable reduction of the fracture, inappropriate implant positioning or a malreduced joint fragment seen on ISO-C but not with routine fluoroscopy. The authors report that the use of ISO-C prolonged each procedure by an average of 7.5 minutes, with no complications reported related to ISO-C utilization.

The Siremobil ISO-C-3D radiation dose for intraoperative CT imaging of similar sized joints has been reported to be comparable to doses measured with low-dose spiral CT protocols for extremity studies (dose-length product [DLP] of 39.9 mGy-cm and 37 mGy-cm, respectively) [8,9]. In theory, the C-InSight scan results in much less radiation, the summary of 15-20 seconds of continuous scanning with a C-arm. The dose of a small joint scan with the C-InSight has not been reported.

Intraoperative use of the ISO-C or C-InSight systems may reveal malreduced scaphoid fractures or malpositioning of fixating

* Corresponding author.
*E-mail address:* shail@hadassah.org.il (S. Luria).

http://dx.doi.org/10.1016/j.otsr.2014.07.038
1877-0568/© 2015 Elsevier Masson SAS. All rights reserved.

devices which may still be corrected during the procedure. Our hypothesis was that 3D scans could better display the quality of fracture reduction and fixation in comparison with fluoroscopy.

## 2. Materials and methods

After obtaining institutional approval and patient consent, all patients between the ages of 18 and 60 treated for acute displaced scaphoid fractures or fracture nonunions were included in the study. Exclusion criteria included non-displaced fractures and pregnancy.

A control group or randomization was not performed. The study protocol was designed so comparison could be made within the same group of patients, where each patient's standard fluoroscopy images served as the control [5]. The 3D scan was made at a point during the operation where the surgeon would normally complete the fixation. In cases in which the result was not satisfactory as depicted on the 3D image, revision was possible. Following a first group of patients evaluated with the ISO-C system, a second group of patients were evaluated with the C-InSight system.

### 2.1. Intraoperative protocol

Fracture reduction and fixation was performed as done routinely under fluoroscopic guidance using a single K-wire (1.1 mm) and bone graft when adequate. In one case, an additional anti-rotation K-wire was used, yet this resulted in additional artifact in the ISO-C scan and in the subsequent cases, an additional wire was not used. When the surgeon was satisfied with the reduction and fixation with the single K-wire, based on the routine fluoroscopy images, typically at the point where placement of the cannulated screw over the wire would occur, the 3D imaging was performed. This decision was made by two of three surgeons – either by two fellowship trained hand surgeons (SL, GZ) or by one fellowship trained hand surgeon (SL) and a hand surgery fellow.

### 2.2. Imaging technique

The imaging techniques:

- the Siremobil ISO-C-3D$^{TM}$ (Siemens AG, Germany) is both a regular fluoroscopic device and a CT-image producer. The system includes two units: a modified C-arm with a motor unit and a computerized image processing work station for intraoperative visualization. The C-arm rotation is isocentric, rotating around a single point in space. The C-arm is automatically and steadily rotated over an arc of 190°. In preset angular steps during this rotation, a set of two-dimensional fluoroscopic images are recorded. From these images, the computer creates real time multiplanar CT images and a three-dimensional reconstruction within five seconds after scanning is completed. During its continuous rotation around a surgical field, the C-arm passes through sterile as well as non-sterile areas. In order to maintain sterility, the surgical field is covered by an extra layer of sterile sheets when scanning is performed. At the end of scanning, these sheets were removed and gloves changed. During scanning, the surgical staff was protected from radiation by portable shields, as recommended by the manufacturer (in addition to the standard lead apron);
- C-InSight (MAZOR Surgical Technologies, Israel) is an add-on to the C-arm which includes an image adaptor connected to the C-arm and a sterile target which is placed on the wrist. A regular C-arm is used, which is not isocentric as is the ISO-C system. The C-arm is manually rotated around the image in an arc of 120 degrees (15–20 seconds). The images taken are analyzed by C-InSight software (60–90 seconds) producing 3D reconstruction of the images taken. The same precautions were taken regarding sterility. No radiation proof shield was used other than the standard lead apron.

It should be noted that in both systems, the wrist is scanned, but the software allows the alignment of the images along the long axis of the scaphoid or along the K-wire, simplifying the analysis of the images.

### 2.3. Imaging analysis

The following specific factors were examined with the fluoroscopy followed by 3D imaging:

- quality of fracture reduction – displacement of the fracture or residual flexion (humpback) deformity. In these cases, revision of the reduction was considered. Quality of reduction was visually estimated by the surgeons and the views showing most displacement measured;
- K-wire position through the center of the proximal part of the scaphoid, as a position commonly accepted for adequate fixation. If not centered, repositioning of the K-wire was considered;
- any extrusion of the K-wire where it exits the scaphoid, in order to enable correct measurement of the screw length. In cases where the K-wire was not found to reach the far cortex of the scaphoid or passed it, K-wire depth measurement was revised.

### 2.4. Final fracture fixation

After satisfactory reduction and fixation of the fracture was achieved, the cannulated screw was placed over the K-wire and additional fluoroscopic imaging was performed to ensure proper fixation.

### 2.5. Data analysis

The primary outcome measure of the study was the intraoperative revision rate. The percent of revisions was compared between groups with a $\chi 2$ test and measured times and radiation compared with the Mann-Whitney U test. The null hypothesis at the $P < 0.05$ level was that there was no difference between the groups. Comparison of artifact and other technical problems was only descriptive due to the different characteristics of the modalities evaluated.

## 3. Results

A total of 25 3D scans were performed, ten with the ISO-C and 15 with the C-InSight. Twenty-four males and one female, with a mean age of 25 (SD 8), were treated with fracture reduction and fixation with a cannulated headless compression screw (Acutrak Mini, Acumed, Hillsboro, OR). Two of the 25 patients were treated for acute fractures. Twenty-three were treated for fracture nonunion with additional bone graft (mean time from fracture – 17 months, SD 15). The use of the ISO-C-3D prolonged the procedure by a mean of 8 minutes (SD 1.7; range 6–10 min) and with C-InSight by a mean of 11 minutes (SD 3.9; range 6–19 min)(Mann-Whitney U test, ns). The average CT dose index (CTDI) for a single study with the C-InSight was found to be 0.72 mGy (SD 0.37). This could be compared with the standard CT scans of the wrists of the patients prior to surgery, which resulted in exposure to a mean CTDI of 19.1 mGy (SD 11.5) (Mann-Whitney U test, $P = 0.001$).

The factors considered for assessment of reduction and fixation, after the 3D scan:

- quality of fracture reduction – in 23 cases, the displacement was measured to be less than 1 mm. In two of the 25 cases, after

Download English Version:

https://daneshyari.com/en/article/4081180

Download Persian Version:

https://daneshyari.com/article/4081180

Daneshyari.com