Three Dimensional Fluoroscan is More Accurate and Repeatable Than Two Dimensional Fluoroscan for Measuring Central Scaphoid Screw Placement in a Cadaver Model

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INTRODUCTION
A commonly accepted treatment method for scaphoid fractures is dorsal percutaneous fixation1,7. This has been shown to decrease the need for cast immobilization and allow faster recovery3,5. For this approach a central screw placement is critical as it provides greater stiffness and load to failure, and allows a longer screw to be inserted which increases screw compression. All of these factors aid in fracture union6. However, the complex shape of the scaphoid bone makes central screw placement difficult, as the main axis cannot be easily visualized. Currently, scaphoid screws are placed using K wires guided under 2D fluoroscopy; however, intra-operative 3D fluoroscopy, which can create a CT reconstruction, is becoming more readily available. The goals of this study are to see if there is a significant difference between 2D and 3D fluoroscopic imaging in measuring screw malpositioning (distance off-center) and if there is a difference in repeatability.

METHODS
Compression screws (Acutrak 4mm x 17.5mm or 20mm, Acumed) were placed into five fresh-frozen cadaveric hands (Age: 48-73, 2 female). All specimens were imaged prior to the study to rule out any existing pathology. The screws were inserted using a dorsal percutaneous approach under traditional 2D fluoroscopy (HD Mini C-arm, Orthoscan). After screw placement the wrists were scanned using a 3D fluoroscopic C-arm (BV Pulsera, Philips).

2D fluoroscopic images were analyzed for malpositioning by measuring the distance between the center of the screw and the midpoint of a line running through the scaphoid and perpendicular to the screw axis (ImageJ, NIH). Measurements were taken at 25, 50, and 75% of the total scaphoid length (Figure 1). It was assumed that the AP and lateral images were perpendicular and the total screw malpositioning would be the hypotenuse of the individual distances. Each image was measured three times to test for intra-operator variability.

RESULTS
The average screw malpositioning found for 2D fluoroscopy was 1.83±0.48mm while 3D fluoroscopy found a displacement of 1.28±0.49mm. These values were significantly different (p<0.005). Repeat measurements (N=3) made on the same images resulted in significantly different measurement errors of 21.1±13.0% in 2D imaging and 6.6±4.6% in 3D imaging (p<0.001).

DISCUSSION
This study showed that there is a significant difference in measurement of screw malpositioning using 2D imaging vs. 3D imaging. A possible reason is that measurements using 2D fluoroscopy assume an elliptical cross-section (Figure 4), which is not representative of the scaphoid’s true cross-section.

These differences in screw malpositioning measurement could have clinical implications. For example, for the specimen depicted in Figure 4, the 2D image showed a greater malpositioning but did not show a cortical breach, while the 3D image did show a breach; this discrepancy is due to the larger scaphoid cross-section in 2D. The case of 3D fluoroscopy detecting a cortical breach while the 2D did not is a critical issue, as a distal cortex breach could impinge on the joint clear space and hinder return to movement. This is a potentially significant benefit that 3D imaging could offer over 2D.

There was also a higher average degree of repeatability in 3D imaging compared to 2D. This suggests that confirming screw location using an intra-operative 3D fluoroscopy or 3D imaging is more reliable, as intra-operator variability is reduced. These errors may vary by operator, as this technique requires the operator to choose the cross-sectional planes by determining the scaphoid axis direction and length. Intra-operator variability was not assessed in this study.

Potential disadvantages of using 3D imaging include increased cost of the 3D fluoroscopy, increased OR time and radiation exposure to run imaging intra-operatively, and training time for clinicians to adjust to the newer imaging techniques. Clinical trials are necessary to determine if the advantages offered by 3D intra-operative imaging outweigh these disadvantages; however, the results of this cadaver based study and others3 are promising for the continued development of 3D intra-operative imaging techniques.

REFERENCES