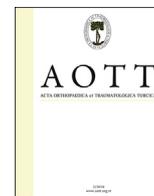


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## Acta Orthopaedica et Traumatologica Turcica

journal homepage: <https://www.elsevier.com/locate/aott>

## Comparison of ultrasound and dorsal horizon radiographic view for the detection of dorsal screw penetration



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### ARTICLE INFO

#### Article history:

Received 27 February 2017

Received in revised form

1 August 2017

Accepted 12 October 2017

Available online 1 November 2017

#### Keywords:

Distal radius fracture

Volar plating

Complications

Ultrasound

Tendon rupture

### ABSTRACT

**Objective:** The aim of this study was to compare the efficiency of dorsal tangential fluoroscopy and ultrasonography in detecting dorsal screw penetration in distal radius volar locking plate applications.

**Methods:** Ten cadaveric forearms were operated. The distal four screws were protruded 0, 1 and 2 mm into each of the second, third and fourth dorsal compartments of distal radius. Dorsal horizon views were taken using fluoroscopy. Each radiographic image was evaluated by two orthopedic surgeons who are blinded to procedure. Sonographic evaluations were performed by an orthopedic surgeon blinded to the procedure. Both dorsal horizon view and ultrasonography assessments were noted by the evaluators whether the tip of the screw penetrated or not the dorsal cortex for each compartment.

**Results:** No significant difference was observed on correct detection of 0 mm, 1 mm and 2 mm screw penetrations at second and third compartments. In the fourth compartment, there was no difference with 0 mm and 2 mm penetrations but correct detection accuracy of 1 mm screw penetration was 87% in ultrasonography group and 71% in dorsal horizon view group.

**Conclusions:** The accuracy of ultrasonography on 1 mm penetration at the fourth compartment is better than dorsal horizon view. However, dorsal horizon view and ultrasonography accuracy is similar for the other compartments and penetration levels. Ultrasonography is a reliable and effective procedure for detection of dorsal screw penetrations.

**Level of evidence:** Level III, Diagnostic study.

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### Introduction

In recent years, volar locked plates, offering lower complication rates and faster clinical recovery, have become increasingly popular for the treatment of distal radius fractures.<sup>1–4</sup> With the increased use of volar locking plates, complications such as tenosynovitis and tendon ruptures resulting from penetration of distal screws through the dorsal cortex have been reported.<sup>3,5,6</sup> A number of radiographic views have been described to detect dorsal screw penetration.<sup>7–10</sup> On the other hand, it has been reported that radiographic view alone is insufficient to detect penetrations in the second and fourth dorsal compartments.<sup>11</sup> Additional supination

and pronation views are required. Computed tomography is one of the techniques that allow better detection of screw penetration.<sup>12</sup>

Ultrasound (US) is one of the methods recommended for the detection and follow-up of dorsal screw penetration.<sup>5</sup> In addition, the scope of US imaging guidance for regional anesthesia is growing rapidly, thus enabling US to become a standard imaging equipment in operating rooms. On the other hand, there are no studies demonstrating the reliability of US for the detection of postoperative screw penetration.

The purpose of this study was to detect the reliability of dorsal horizon view (DHV) and US for the detection of dorsal screw penetration.

### Materials and methods

In this study, Acumed Acu-Loc volar distal radius plates were inserted via a standard approach in distal radii of 10 cadavers. All

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Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

procedures were performed by two fellowship-trained hand surgeons. The first 3.5 mm nonlocking cortical screw was placed through the slot in the plate (Fig. 1). The position of the plate relative to the articular surface was then fine-tuned by sliding the plate proximal or distal under fluoroscopy (InSight Fluoroscanner; Hologic, Bedford, MA) (Fig. 2). After 4 rows of screws were placed from the radius towards the ulna, the dorsal surface was exposed and the location and compartments of screw penetrations were noted (Fig. 3). Screws were placed such that they protruded 0, 1 and 2 mm and dorsal horizon views (DHV) were taken as described by Haug et al.<sup>8</sup> Each image was printed out and evaluated by two blinded orthopedists (certified in hand surgery) to detect the penetrations and the penetrated compartments (DHV1–DHV2) (Fig. 4). US examinations were performed by a 10-years experienced radiologist (US1) and a 5-years experienced orthopedist (US2), blinded to the study. They evaluated screw penetrations and compartment determination in each case (Fig. 5). Both surveyors used a S-nerve machine (SonoSite Inc., Bothell, WA, USA) with a linear probe (6–15 MHz, SonoSite Inc., Bothell, WA, USA).

We analyzed the data for sensitivity in determining the presence of screw penetration at 95% confidence intervals. The Pearson correlation test was used to assess the inter-observer agreement and the Mann–Whitney U test to compare the means of the results of DHV and US. P values were declared statistically significant if 0.05 or less.

## Results

Table 1 shows the sensitivity in detecting dorsal cortical screw penetration of the distal radius. Positive correlation between the observers was  $p < 0.01$  in the DHV group and  $p < 0.05$  in the US group (Table 2). In addition, there was a positive correlation between US2 (5-year experienced orthopedist) and DHV observers ( $p < 0.05$ ). No statistically significant difference was noted in accurate detection of 0 mm, 1 mm and 2 mm of screw penetrations in the 2nd and 3rd compartments and 0 mm and 2 mm of screw penetrations in the 4th compartment between DHV and US.

The sensitivity of DHV for the detection of 1 mm of screw penetration in the 4th compartment was 71% and that of US was 91% ( $p < 0.05$ ).

## Discussion

Irritation and attritional rupture of extensor tendons are important complications of distal radius fixation. The initial injury predisposes the extensor tendons to rupture, and surgery further increases this risk when the dorsal cortex is violated by a screw.<sup>7</sup> The anatomical characteristic of the distal surface of the dorsal

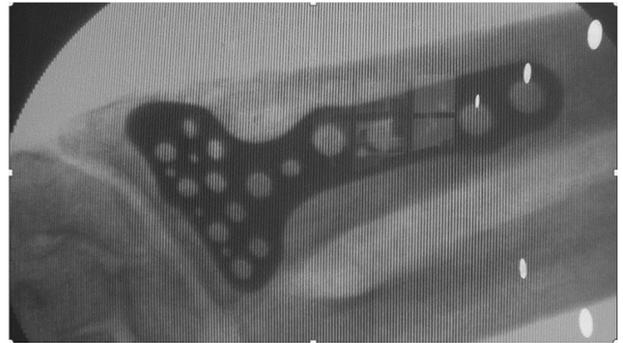


Fig. 2. Radiological view after insertion of first cortical screw.



Fig. 3. Operative view via dorsal approach for determination of screw penetrations.

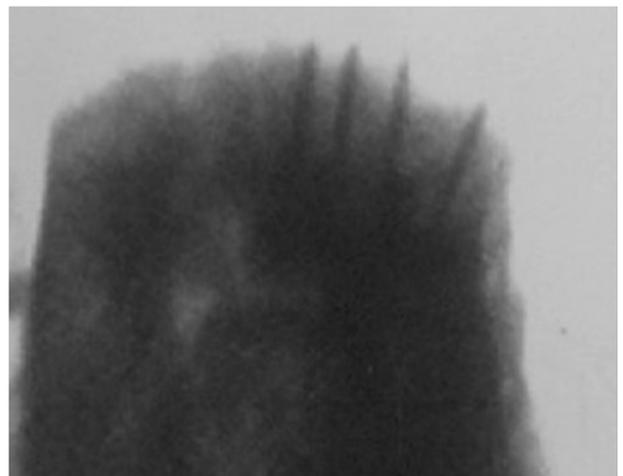


Fig. 4. Radiological dorsal horizontal view.



Fig. 1. Operative view after insertion of first cortical screw.

face is the main cause of failure in detecting screw penetration.<sup>13,14</sup> Ozer–Toker reported that the standard anteroposterior and lateral radiographic views were insufficient in detecting screw penetration after locking plate fixation.<sup>7</sup> Therefore, there are a number of studies describing fluoroscopic imaging at the optimum position for the detection of screw penetration. After these studies, the standard wrist, elbow position was not described for the detection of screw penetration. In a cadaveric study by Ozer et al, the wrist was positioned at a minimum 70° flexion using a goniometer and X-ray beam was directed in the sagittal plane of the Lister's

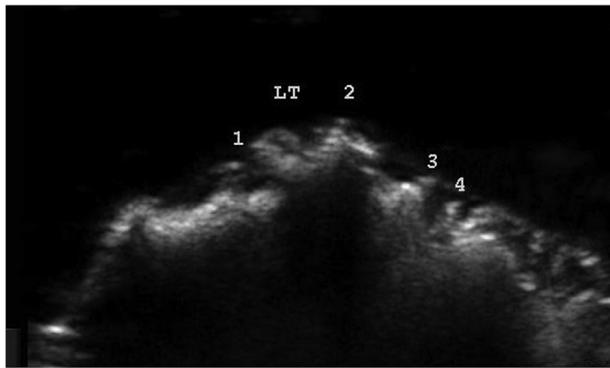


Fig. 5. Ultrasonographic view of dorsal cortex. (Numbers defines the screws and LT: Lister's tubercle).

Table 1

Observer sensitivity of ultrasound and dorsal horizontal view (expressed as percentage) in detecting screw penetration.

Screw penetration, mm	0 mm			1 mm			2 mm		
	2	3	4	2	3	4	2	3	4
compartment	2	3	4	2	3	4	2	3	4
DHV	100	100	100	81	81	71	100	100	87
US	100	100	100	90	100	87	80	100	91
<b>Total No. Prominent Screws</b>	<b>9</b>	<b>10</b>	<b>21</b>	<b>9</b>	<b>10</b>	<b>21</b>	<b>9</b>	<b>10</b>	<b>21</b>

Table 2

Interobserver correlations.

	DHG1	DHG2	USG1
DHV1	1	.933**	.749*
DHV2	.933**	1	.771*
US	.749*	.771*	1

DHV: Dorsal Horizontal View.

US: Ultrasound.

\* Correlation is significant at the 0.05 level (2-tailed).

\*\* Correlation is significant at the 0.01 level (2-tailed).

tubercle. They reported that the radiograph failed to detect screw penetrations in the 2nd and 4th compartments. They emphasized that the 45° of supination and pronation oblique views should also be obtained to detect screw penetrations.<sup>8,10,14</sup> Haug et al, suggested that the optimal position for the detection of screw penetration could be obtained by placing the wrist in maximum flexion and the elbow at 15° (radiohumeral angle).<sup>8</sup> It was found in this study that DHV had a sensitivity of 86.7% for the detection of screw penetration, but, failed to detect 1 mm of screw penetration particularly in the 4th compartment. The results we obtained, though with different techniques, are consistent with those reported by Ozer et al. On the other hand, several problems have been reported with the use of DHV for the detection of screw penetration in patients with comminuted fracture of the dorsal radius and/or those with limited peri- and post-operative flexion.

The accuracy of dorsal tangential view for the detection of screw penetration has been demonstrated in computed tomography studies. Brunner et al changed 11 screws peri-operatively, which they considered to be protruding beyond the dorsal cortex during surgery. They found no cases of perforations in the final images.<sup>12</sup> They reported that even though computed tomography enables better measurement of the screw length, dorsal tangential view method was easier and as effective as computed tomography. In addition, the routine use of computed tomography is not recommended since it is a time-consuming and cost-intensive procedure which is also associated with radiation exposure.<sup>8,12</sup>

It has been reported in the literature that US is a safe method that can be used for the detection of screw penetration and the follow-up of complications following screw penetration.<sup>5</sup> On the other hand, no studies so far have evaluated the sensitivity of US and made a comparison between US and DHV. In this study, US allowed a better detection of 1 mm of screw penetrations in the 4th compartment compared to DHV. The evaluation of inter-observer agreement reveals that the agreement between DHV observers was higher. The lower agreement between US observers was attributed to the difference in observers' level of experience. We believe that as the level of experience increases, more satisfactory results can be obtained in the detection of screw penetration.

Previous studies recommended the change of screw length or the removal of volar locking plate, in the presence of nonunion, to prevent complications such as synovitis and rupture in screw prominence greater than 2 mm.<sup>5,12</sup> On the other hand the correlation between the length of the screw and affected compartment should be discussed.<sup>15</sup> In this study, DHV was found to be as sensitive as US for the detection of 2 mm of screw prominence.

This study has several limitations:

- I) The study was conducted on non-comminuted radii,
- II) Only one type of plate was used,
- III) The interpretation of US images was dependent on the skill of the performer.

Despite these disadvantages, we believe that US can be used to detect screw penetration in clinical practice in the perioperative and postoperative period. US is associated with longer duration of training and longer application time compared to DHV, which may affect its use perioperatively. On the other hand, as a cost-effective and real time examination method, US can be used effectively without additional radiographies and radiation exposure.

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