Dorsal tangential view of the wrist to detect screw penetration to the dorsal cortex of the distal radius after volar fixed-angle plating

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Abstract

Background Extensor tendon irritation and attritional tendon ruptures are well-recognized complications, secondary to dorsal screw penetration following volar plating of the distal radius. Lateral and oblique views of the wrist have limited ability to detect such penetration, particularly at the ulnar side of the Lister's tubercle. In this report, we conducted an intraoperative fluoroscopic study to determine dorsal screw penetration in various positions of the wrist/forearm and compared the standard radiographic views (lateral, supination, and pronation views) with dorsal tangential view of the wrist.

Materials and Method Standard lateral, oblique (in pronation and supination), and dorsal tangential views were obtained in 27 consecutive patients undergoing fixation a distal radius fractures using a volar plate. The number of penetrating screws in each dorsal compartment (second, third, fourth) was recorded in each view. Dorsal tangential view was obtained using a mini C-arm intraoperatively and sending the beam parallel to the dorsal aspect of the wrist in transverse plane.

Results Of the 125 distal screws, 8 screws were seen to be penetrating the dorsal cortex in lateral and oblique views, whereas 11 screws were detected in dorsal tangential view.

Conclusion The screw penetration to the third dorsal compartment was missed in standard views, but visualized in dorsal tangential view. We recommend the use of dorsal

tangential view in addition to standard lateral and oblique views during volar plating of the distal radius.

Keywords Distal radius fracture · Fluoroscopy · Volar-fixed angle plating

Introduction

Extensor tendon irritation and attritional tendon ruptures are well-recognized complications, secondary to a number of factors including screw penetration to the dorsal cortex following volar-locked plating of the distal radius [1–3, 5, 7, 8, 10, 11, 13, 16, 17]. Intraoperative detection of improper screw placement is essential to prevent such complication. In addition to lateral view of the wrist, pronation, and supination views were described to detect dorsal screw penetration [4, 15]. Despite their judicious use intraoperatively, dorsal screw penetration may still be unrecognized, particularly at the ulnar side of the Lister's tubercle [14]. In this study using a mini C-arm intraoperatively, we obtained dorsal tangential view (DTV) along with standard views to detect dorsal screw penetration to the distal aspect of the radius [6].

Patients and Method

DTV of the wrist: While the patient is lying supine on the operating table, the examiner controls the forearm and hand with the wrist flexed at 75°. The forearm is placed between the two ends of the mini C-arm in the transverse plane (Fig. 1a), a continuous sequence of images is obtained while the forearm is moved toward the midline (Fig. 1b) until Lister's tubercle is seen in its full height (Fig. 1c). The

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Fig. 1 **a** Dorsal tangential view was obtained by sending the X-ray beam parallel to the dorsal aspect of the distal radius as seen in this picture. **b** Thin arrow shows the direction of the X-ray beam directed parallel to the dorsal aspect of the forearm. During live sequence shooting, forearm is moved to the midline as shown by the thick arrow, until the optimal view is obtained (1C). **c** From left to right arrows show radial styloid, Lister's tubercle and ulnar/dorsal corner of the distal radius. **c** Arrows show prominent landmarks on the dorsal aspect of the distal radius, from left to right, radial styloid, Lister's tubercle, dorsal corner of the distal radioulnar joint on the radial side

optimal position of the hand and forearm, showing the longest distance between the tip of the Lister's tubercle and the bottom of the EPL groove (third dorsal compartment), defines the DTV of the wrist.

Between July 2009 and December 2009, 27 patients underwent open reduction and internal fixation of a distal radius fracture using volar-locked plating. Average age of patients was 45 (range 19–67). Fifteen fractures had AO type A fracture, 13 had type B, and 12 had type C. All surgeries were performed using the standard volar approach and one of the two distal radius locking plates (Synthes, Monument, CO; Accumed, Hillsboro, OR), and a mini C-arm (Fluoroscanner, Scottsdale, AZ) [12]. Following reduction and placement of the plate and screws standard wrist views in lateral, 30 and 45° of pronation and supination were obtained along with DTV. Screws, seen to be penetrating the dorsal cortex for 1 mm or more, were exchanged with shorter screws before the closure. Total number of screws and the number of screws penetrating the dorsal cortex were noted in each view. The distribution of screws was grouped in three zones as described in Fig. 2.

Results

Of the 125 distal screws placed in 27 patients, 11 of them were detected to be longer than 1 mm in at least one of the six views taken (Table 1). Three of these were penetrating in zone 1 and detected in supination view and in DTV. Only one of four screws penetrating in zone 2 was detected by pronation view, while DTV visualized all four penetrations to the dorsal cortex (Fig. 3). Finally, three screws penetrating in zone 3 were seen in both pronation and DTVs.

Discussion

In this study, we report our experience using DTV in the operating room. A similar fluoroscopic view has recently

Fig. 2 (Small Box) Zones 2, 3, and 4 represent extensor compartments of the wrist. Arrows 1 and 2 show the projection of the X-ray beams of the lateral and pronation views, respectively. Note that fluoroscopic images are unable to detect any screw penetration in colored zone underneath arrow #2

Table 1 The distribution of all screws in zones of the dorsal extensor compartment and the number of detected screws penetrating the dorsal cortex

	Zone 2	Zone 3	Zone 4
Total # of (distal locking) screws used	54	32	39
Total # of penetrating (distal locking) screws	4	4	3
Total # of penetrating screws detected in each view			
Lateral	0	0	1
Supination ^a	4	0	N/A
Pronation ^a	N/A	1	3
DTV ^b	4	4	3

^a this view was taken at 30 and 45°; ^b DTV Dorsal tangential view

been reported by Jacob et al. using an upright full-size C-arm [6]. Authors on their letter to the editor have shown an upright C-arm used to obtain an image in the vertical plane and reported having difficulty getting a clear picture when the wrist is swollen without any comparison provided to standard views of the wrist. We have been using a smaller size fluoroscan with higher resolution to obtain the view in transverse plane, and we are able to get a clear picture even in severely swollen wrists.

Fig. 3 a Fluoroscan outputs taken during an open reduction and internal fixation of a distal radius fracture on a 25-year-old female patient. First three series are taken in lateral, supination, and pronation views have failed to detect screw penetration to the dorsal cortex. **b** Dorsal tangential view shows the screw violating the dorsal cortex

DTV of the wrist is a method of fluoroscopic profiling of the dorsal aspect of the wrist and effectively shows dorsal screw penetration in zones 2, 3, and 4 on the dorsal aspect of the radius. Compared to standard views of the wrist in lateral and oblique planes, the ulnar side of the Lister's tubercle (floor of the third dorsal compartment) is better visualized with this method. The main limitation of the current study is in its methodology that it was carried out in the operating room, and therefore, cannot conclusively determine the number of screw penetrations to the dorsal cortex as no additional incisions were made on the dorsum of the distal radius. Due to absence of direct visualization or CT scan, we do not claim that this view can be used as a gold standard to detect all screw penetrations on the dorsal cortex. This may be the subject of another investigation in the future.

Intraoperatively, fluoroscopic evaluation of dorsal screw penetration is challenging given the complex angular geometry of the distal radius. Standard PA and lateral images of the wrist are inadequate to confirm proper screw position and length for multiplanar tilts of the distal radius. Thus, several investigators used oblique views of the wrist, either supinating or pronating the forearm, aligning the X-

ray beam parallel to the dorsal cortex in question [4, 15]. Although these anatomic views have proven accurate, screw penetrations *specifically* occurring on the floor of the third compartment were not addressed. On a cadaveric study evaluating the reliability of the pronation and supination radiographic views in identifying dorsal screw penetration after volar-locked plating of the distal radius, investigators concluded that pronosupination views were adequate to assess screw length and recommended their use in addition to standard and lateral views, intraoperatively [9]. They did not, however, address the length of the Lister's tubercle as screws penetrating into the gray zone (in Fig. 2) may be missed in pronation and lateral views. In a recent study, Pichler et al., using CT and a 3D anatomy model of the distal radius reported an average 3.4 mm (range 2.2–5.8 mm) distance between the lowest point of the EPL groove and the peak of Lister's tubercle [14]. Clearly, this distance is enough to hide two to three full threads of a screw. While we agree that pronosupination views can effectively show screw penetrations in most individuals, they may not show it in every case given the substantial anatomic variation in Lister's tubercle height.

It is not clear at this point whether the routine use of DTV at the clinical setting can reduce the incidence of tendon ruptures, as many other factors are linked to such occurrence, including over drilling on the dorsal cortex, the irritation of fractured fragments, entrapment of the extensor tendon between fractured fragments, and idiopathic ruptures as seen in minimally displaced distal radius fractures [2, 5, 7, 10, 13, 16]. To avoid dorsal screw penetration, one can always insert screws that are 2–4 mm shorter than the measured screw length. While this may be an acceptable method to fix an area of comminution on the dorsal cortex, it may not be advisable in the presence of a 3-part intra-articular fracture, where a sizeable piece of dorsal cortex also makes the joint surface of the lunate fossa. We believe that the use of DTV as an adjunct to the standard lateral and pronosupination views has the potential to increase the likelihood of detecting dorsal screw penetration, intraoperatively.

Conflict of Interest Authors have no conflict of interest to disclose.

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