Screw length in volar locking plate fixation for distal radial fractures

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ABSTRACT

Purpose. To develop a reference for the distal screw length in volar locking plate fixation for distal radial fractures in an East Asian population.

Methods. 12 pairs of forearm specimens from 11 male and one female East Asian cadavers were scanned using computed tomography. On sagittal images of the distal radius, the mean cortex-to-cortex distance of 8 quadrants was measured as a reference for the distal screw length. In addition, intra-operative 3-dimensional fluoroscopy of 10 male and 10 female patients who underwent volar locking plate fixation for distal radial fractures was used to validate the distal screw length in the cadaveric reference. 76 distal locking screws were applied in the 8 quadrants; their cortex-to-cortex distances were measured.

Results. The mean cortex-to-cortex distances at quadrants A, B, C, D, E, F, G, and H were 15.4 mm, 19.6 mm, 20.8 mm, 20.0 mm, 13.3 mm, 18.0 mm, 18.8 mm, and 17.4 mm, respectively. In 45% of the specimens, the 2 screws inserted at quadrants C and D were longest. Distal screws (quadrants A to D) were significantly longer than proximal screws (quadrants E to H) [p=0.02]. In intra-operative 3-dimensional fluoroscopic images, 2 of the 76 distal locking screws penetrated the dorsal cortex (one in quadrant A and one in quadrant F). The mean screw length was 88.0% of the cortex-to-cortex distance. Referenced to the cadaveric data, 88.2% of the screws could be safely inserted without penetrating the dorsal cortex, and the remaining 11.8% of screws (5 at quadrant D, one at quadrant B, and 3 at quadrant C; all in female patients) could potentially cause dorsal cortex penetration of 2 to 4 mm. In male patients, the mean screw length was 76.1% of the cortex-to-cortex distance based on the cadaveric reference. In female patients, when the screw length was 4 mm less than the cadaveric reference, the mean screw length would be 72.0% of the referenced cortex-to-cortex distance, with no dorsal cortex penetration.

Conclusion. In female patients, the screw length should be 4 mm less than the cadaveric reference to avoid dorsal cortex penetration.

Key words: radius fractures; tendon injuries; volar plate
INTRODUCTION

The incidence of distal radial fracture is 108.6 to 260 per 100 000 person year.1–3 Dorsal plate fixation may lead to tendon irritation, tenosynovitis, and rupture because the extensor tendons are in close contact with the bone.4,5 Volar locking plate fixation is preferred,5,7 as the flexor tendons are further away from the bone surface.8 Nonetheless, flexor and extensor tendon irritation (including extensor pollicis longus tendon ruptures and extensor tendon tenosynovitis) is common.9 Delayed extensor tendon rupture secondary to screws penetrating the dorsal cortex has also been reported.10 The drill bit or screw tips protruding into the third extensor compartment or bone fragments or dorsal gapping may predispose the extensor pollicis longus tendon to injury.11 This may be due to inaccurate measurement of screw length, owing to comminution of the dorsal cortex or inability to detect penetration intra-operatively.12,13 This study aimed to develop a reference for the distal screw length in volar locking plate fixation for distal radial fracture in an East Asian population.

MATERIALS AND METHODS

12 pairs of forearm specimens from 11 male and one female East Asian cadavers (mean±standard deviation [SD] age, 71.4±10.7 years; mean±SD weight, 49.3±8.8 kg; mean±SD height, 160.2±7.8 cm) were scanned using computed tomography (Discovery PET/CT 690 VCT, GE Healthcare) at 0.625 mm slice thickness. The gantry was centred over the wrist and straight up (0º). The images were reformatted into a sagittal cut at 0.6 mm slice thickness parallel to the long axis of the radius. The cortex-to-cortex distance was measured from volar to dorsal at 15º angulation to simulate the locking hole orientation in most volar locking plates (Fig. 1). The distance was measured at 8 evenly spaced quadrants arranged in 2 rows from radial to ulnar aspect (distal row: A to D; proximal row: E to H) in the coronal plane (Fig. 2).

Figure 1 The cortex-to-cortex distance is measured from volar to dorsal at 15º angulation. The distal row (quadrants A to D) and proximal row (quadrants E to H) are measured (a) 4.5 mm and (b) 9.5 mm from the joint line, respectively.

Figure 2 The cortex-to-cortex distance is measured on 8 evenly spaced quadrants arranged in 2 rows from radial to ulnar aspect (distal row: quadrants A to D; proximal row: quadrants E to H).
their cortex-to-cortex distances were measured. Repeated measures ANOVA was used for analysis. A p value of <0.05 was considered statistically significant.

RESULTS

In the 12 pairs of forearm specimens, the mean±SD cortex-to-cortex distances at quadrants A, B, C, D, E, F, G, and H were 15.4±2.3 mm, 19.6±2.5 mm, 20.8±2.7 mm, 20.0±3.4 mm, 13.3±2.7 mm, 18.0±2.6 mm, 18.8±3.2 mm, and 17.4±3.6 mm, respectively. Assuming that the screw-length increment was 2 mm and that the longest screw without penetrating the dorsal cortex was used, in 95% of the specimens the screws inserted to quadrant A were shorter than those inserted to other quadrants, whereas in 45% of the specimens the screws inserted at quadrants C and D were longer than those inserted to other quadrants (85% for the quadrant C and 15% for the quadrant D). Distal screws (quadrants A to D) were significantly longer than proximal screws (quadrants E to H) [p=0.02, repeated measures ANOVA]. Screws inserted at quadrants D and H had the highest standard deviation in length.

In intra-operative 3-dimensional fluoroscopic images of the 20 patients, 2 of the 76 distal locking screws penetrated the dorsal cortex (one in quadrant A and one in quadrant F). The mean screw length was 88.0% of the cortex-to-cortex distance. Referenced to the cadaveric data, 88.2% of the screws could be safely inserted without penetrating the dorsal cortex, and the remaining 11.8% of screws (5 at quadrant D, one at quadrant B, and 3 at quadrant C; all in female patients) could potentially cause dorsal cortex penetration of 2 to 4 mm. In male patients, the mean screw length was 76.1% of the cortex-to-cortex distance based on the cadaveric reference. In female patients, when the screw length was 4 mm less than the cadaveric reference, the mean screw length would be 72.0% of the referenced cortex-to-cortex distance, with no dorsal cortex penetration.

DISCUSSION

The Lister tubercle and the trapezoidal shape of the dorsal cortex make the detection of dorsal screw protrusion difficult on fluoroscopy (Fig. 3).12,14 In one study, 4 (26.6%) out of 15 patients had dorsal screw protrusion; 50% occurred in screws >5 mm ulnar to the Lister tubercle, even with measurement of the cortex-to-cortex distance and confirmation of the screw length using fluoroscopy.12 The ulnar-most quadrants (D and H) had the highest standard deviation in screw length and are difficult to visualise on fluoroscopy. The mean screw penetration is longer in ulnar-most quadrants than in central quadrants because of the trapezoidal shape of the dorsal cortex.13,14 The pronation view to align the ulnar dorsal cortex with the radiographic beam enables better assessment of screw penetration. Repeat measurement and confirmation using the pronation view and the dorsal horizon view is needed if a longer screw (than screws in other quadrants) is used. When in doubt, a shorter screw is recommended, as the construct stiffness of locked unicortical fixation of >75% length is similar to locked bicortical fixation,15 whereas dorsal cortex penetration of even 1 mm may produce tendon or nerve complications.14 In addition, fixation of the dorsal cortex is not useful because it is thin.14 Rather, surgeons should aim to engage the dorsal subchondral plate line, which is parallel to the radial shaft on lateral radiographs. Nonetheless, the screw length differs with different screw trajectory. Manufacturers may consider providing lists of screw length according to plate designs and for various populations for surgeons’ reference.

One limitation of the study was that only one pair of female cadaveric forearms was available for
computed tomography. The difference between male and female in forearm measurements was not known, because no statistical test could be made. All female measurements at various quadrants were shorter than that of male by a mean of 2.8 (range, 2.24–4.40) mm. This was consistent to the suggestion of using screws 4 mm shorter than the cadaveric reference. The inclusion of one female cadaver decreased the mean screw length by 0.23 (range, -0.19 to -0.37) mm, which did not affect the results in males.

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DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES