Anatomy of the distal volar radius and its implications on volar plate osteosynthesis

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Aim: Volar plate fixation of distal radius fractures has become a standard procedure. Anyway descriptions of the diverse morphology of the distal volar radius are rare in literature. Purpose of this anatomical study was to explore the different circular arc radiuses of the distal volar radius and the implications on volar plate osteosynthesis.

Method: The profile of the volar distal radius of one hundred cadaver specimens has been measured by using a common profile gauge. Profiles were copied to paper and analyzed by using calibrated curve templates.

Result: The measurements demonstrate clearly differing volar circular arc radiuses between the radial and ulnar side in a total of 55 percent.

Conclusion: This characteristic may lead to a false rotation position of the distal fracture fragment, following volar plate osteosynthesis. In addition, suboptimal plate fitting due to discrepancy between plate angle and volar radius angle may lead to an incorrect plate position.

Volar plate fixation with use of either a locking plate or a neutralization plate has become increasingly popular among surgeons for the treatment of dorsally comminuted distal radial fractures. When doing volar plating of radius fractures, we observed a considerable variation in the morphology of the distal radius. Research in the literature reveals rare information about the anatomic variations of the distal radius. The objectives of this study were as follows: 1. to explore the different circular arc radiuses of the distal volar radius surface and their occurrence frequencies; 2. to determine in which specific cases established volar plates lead to an unsatisfying result.

Materials & methods

The forearms of one hundred cadaveric specimens (55 left, 45 right) preserved according to Thiel's method where investigated, mean age being 72.5 (59-98 years) (1). Extremities with arthrosis, evidence of trauma or other pathological changes were excluded from this study. After the complete dissection of the bone the width was measured by using a sliding caliper. The greatest width and the width 5cm proximal to the tip of the styloid process of the radius were recorded. The profile of the volar distal radius was quantified by exerting a common profile gauge in the axis of the shaft. Profile measurements were performed in two different zones: 1) in a 5 mm distance to the radial edge and 2) in a 5 mm distance to the ulnar edge. The measured profiles were copied to paper by using a pencil. Profiles were analyzed by using calibrated curve templates (Figure 1).

Student's t-test was used for statistical analysis, a p-value of 0.05 or less was considered statistically significant.

Results

The maximum radius width averaged out at 34.9 mm (±3.1 mm, 28 – 41 mm), the radius width 5cm proximal to the tip of the styloid process amounted in mean

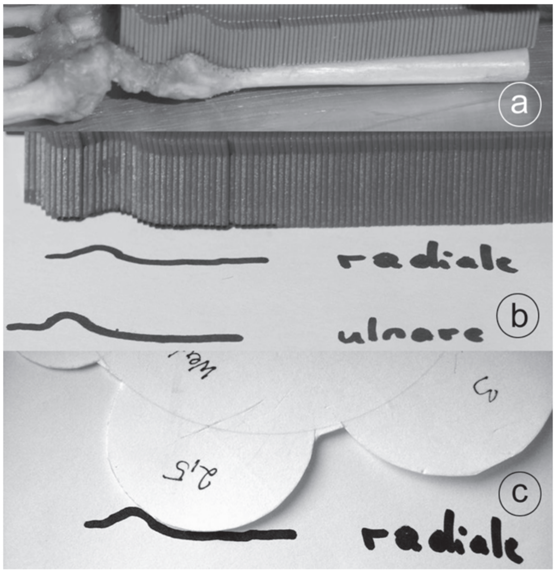

Figure 1: a. measuring method to quantify the profile of the volar distal radius by using a profile gauge. b. measured profiles were copied to paper by using a pencil. c. profiles were analyzed by using curve templates

16.5 mm (±2.4 mm, 11 – 29 mm); we asserted no significant side differences. The measurements demonstrate a distinct gender difference with male having an on average wider radius than women (maximum width: +2.7 mm; proximal +1.6 mm). The circular arc radius of the distal volar surface amounted in mean 2.6 cm (±0.98 cm, 1 – 6 cm) on the radial and 2.3 cm (±0.95 cm, 1 – 6 cm) on the ulnar side (Figure 2 and 3). No significant statistical correlation between

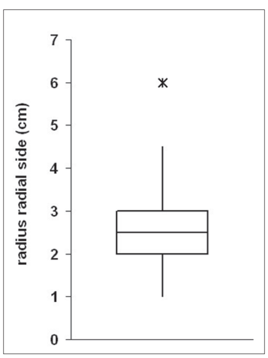

Figure 2: vertical boxplot of different radiuses measured on the radial side in centimetre.

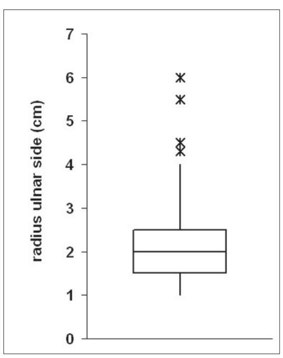

Figure 3: vertical boxplot of different radiuses measured on the ulnar side in centimetre.

gender and these measurements could be detected. The circular arc radius was equal (±0.3 cm) in 45 percent, but in a total of 55 percent distinct differences between the radial and the ulnar side could be discovered. The statistical evaluation shows in 63.2 percent an in mean 0.88 cm (±0.57 cm, 0.1 – 3 cm) larger circular arc radius on the radial side. In these cases the volar shape of distal radius levels towards the radial side. In 36.8 percent the circular arc radius flattens towards the ulnar side, difference between radial and ulnar side amounted in mean 0.51 cm (±0.39 cm, 0.1 – 2 cm). We found no significant statistical correlation between the radius widths and the volar circular arc radiuses.

Discussion

Volar plate fixation of distal radial fractures aiming in the anatomical reconstruction has become a standard procedure in past few years. Nevertheless descriptions of the diverse morphology of the distal volar radius are rare in literature: Solgaard measured on 57 normal radiographs of the wrist volar tilt (average 12 degrees), the radial angulation (average 23 degrees) and the length of the radial styloid (average 12 mm)(2). Yoshida et al. studied radial inclination, ulnar variance, volar tilt, sigmoid notch inclination and ulnar seat inclination using 91 joints of the hand from 51 anatomy cadavers (3). Dumont et al. explored the torsion profiles of the radius and ulna assessed with cross-sectional magnetic resonance imaging in order to detect rotational malunion of the radius and ulna (4). Andermahr et al. analyzed measurements of forty eight 3D computed tomography scans of the distal radius to quantify the anatomy of the volar part of the lunatefacet of the distal radius (5). Moreover, in anatomical benchmark books descriptions of the anatomical variations concerning the volar distal radius are imprecise (6–8). Literature is blank concerning the differences of the circular arc radiuses between radial and ulnar side.

Diverse papers can be found, dealing with the complications following volar plate fixation of distal radial fractures. Fuller et al. monitored the postoperative pressure in carpal canals in ten patients after volar plating. The authors do not recommend routine prophylactic carpal tunnel release after volar plating of distal radius fractures (9). Benson et al. described two case reports, examined six cadaveric specimens and retrospectively reviewed ten selected patients in order to evaluate possible technique refinements to minimize damage to the extensor pollicis longus tendon during volar plating of the distal radius (10). Nunley et al. report a delayed rupture of the flexor pollicis longus tendon after inappropriate placement of the pi plate on the volar surface of the distal radius (11). Recent studies proof that the correct plate position is of significant importance (12,13). Radial shortening is significantly greater when positioning the plate suboptimal. Rigidity of the plate systems is significantly higher when distal screws are placed close to the subchondral zone (13). In order to avoid injuries to the deep flexor tendons, angle-stable implants should be likewise perfectly fit to the bone. Distant angle-stable volar plates may consummately fixate the fracture, but clearly endanger anatomic structures (14). Rozental et al. describe two patients suffering from irritation of the flexor carpi radialis tendon with concomitant subluxation of the flexor pollicis longus tendon over the plate, making hardware removal necessary (15).

The measurements demonstrate clearly differing volar circular arc radiuses between the radial and ulnar side in a total of 55 percent. Presently many established implants for volar radius plating are plane between radial and ulnar side. Suboptimal plate fitting due to differences between plate angle and volar radius shape may lead to an incorrect plate position. Referring to recent literature suboptimal plate position is known to be accountable for higher complication rate (12,13). Fixating two differing circular arc radiuses to a plane surface may lead a false rotational position of the distal fracture fragment. According to statistical results incorrect rotational position may be expected in 55 percent. Thus primary aim of an anatomical fixation of distal radius fracture by means of volar plating might not be fulfilled in these cases.

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