Original article

Distal volar radial plates: How anatomical are they?

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1. Introduction

Distal radial fractures are the most common upper extremity fracture and account for 15% of all fractures [1,2]. Since Abraham Colles' first description in 1814 [3], their treatment has continued to evolve, with open reduction and internal fixation (ORIF) using volar locking plate technology becoming increasingly employed with the aim to restore function through anatomical reconstruction of the fracture [4,5]. Modern volar plating systems were introduced in the 1990s and have been reported to provide excellent biomechanical strength [6] with fewer reported soft tissue complications than dorsal plates [7]. They act as a template for fracture reduction [6] and promote early wrist motion by decreasing the period of immobilisation [8].

The majority of current volar plate designs incorporate a volar cortical angle (VCA), i.e. the angle subtended between the volar lip and the shaft of the distal radius, of 25 degrees across the entire width of the plate [9–13]. To date there exists limited evidence within the medical literature to suggest that this VCA is anatomically accurate. Bassi et al. (2003), performed a review of lateral wrist radiographs and concluded that the mean VCA was measured to be 37 degrees [14]. However because this study relied on plain lateral radiographs only, it was not possible to determine any variation within the VCA across the width of the distal radius. Given that the majority of volar plate designs have the same volar angle across their width, any variation in VCA within the same distal radius may prevent accurate anatomical fixation. This has been confirmed in anatomical studies that have demonstrated the geometry of the volar surface of the distal radius to be extremely complex [15–17]. It is well recognised that in order to achieve good functional results following ORIF, an accurate reconstruction of distal radial anatomy is necessary [18]. Hence if the VCA of current volar plate designs do not reflect the normal anatomy of the distal radius, anatomical reconstruction may be hindered. Therefore the aim of this study is to determine whether the VCA in uninjured distal radii corresponds accurately with modern volar plate designs.

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http://dx.doi.org/10.1016/j.otsr.2013.11.014
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Fig. 1. Coronal CT image of a distal radius, with the medial, middle and lateral lines of reference displayed.

2. Method

We performed a radiological study of one hundred consecutive Computed Tomography (CT) scans of the wrist in adult patients. All patients in this study were being investigated for pathologies other than distal radius fractures. Paediatric cases were not included in this study. For each case, demographic data including age and sex of the patient was collected.

From the coronal views, the distal radius was divided into 3 standardised lines of reference for analysis (Fig. 1). The lateral line corresponds with the midpoint of the scaphoid fossa, the middle line at lateral edge of the lunate fossa and the medial line at the medial edge of the lunate fossa.

Using the same lines of reference, the corresponding points on sagittal CT sections were used to measure the volar cortical angle (VCA). A line was drawn along the volar surface of the shaft of the distal radius. A second line was drawn parallel to the volar cortex of the distal radius (volar cortical line). The angle between these two lines was measured and represented the VCA (Fig. 2). Therefore for each distal radius, three separate measurements of the VCA were performed in order to determine if the VCA varied across the volar surface of the bone.

Fig. 2. Measurement of the volar cortical angle (VCA) on the sagittal CT image of the distal radius.

2.1. Statistical analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Corp, Seattle, USA). To confirm that the VCAs in the respective groups fitted a Gaussian distribution, Kolmogorov-Smirnov tests were performed prior to statistical analysis. In order to compare the lateral, middle and medial VCA, an Anova analysis was performed with post hoc paired t-tests used to ascertain which group was statistically significant. An alpha value of 0.05 was considered statistically significant.

3. Results

One hundred CT scans of the distal radius were analysed. Sixty seven were male and 33 were female. The mean age of the patient was 37.4 years (s.d. ± 15.2). The mean VCA was 33 degrees (s.d. ± 5.1 degrees). The distribution of mean VCA is shown in Fig. 3, demonstrating that 96% of cases had a mean VCA greater than 25 degrees.

3.1. Comparison of VCA at different locations

The mean lateral, middle and medial VCA was 31, 33.8, and 34.1 degrees respectively (Anova, P < 0.0001). Paired t-tests showed that the lateral VCA was statistically significantly smaller than the middle and medial VCA (P < 0.0001, Fig. 4).

Fig. 3. Distribution of mean VCA.

Fig. 4. Mean lateral, middle and medial VCA measurements.

Please cite this article in press as: Evans S, et al. Distal volar radial plates: How anatomical are they? Orthop Traumatol Surg Res (2014), http://dx.doi.org/10.1016/j.jotsr.2013.11.014
3.2. Comparison of age and sex on VCA

There was no correlation between age and mean VCA (Pearson correlation $R^2 = 0.18$).

The mean VCA in males was significantly greater than the VCA in females (33.7 degrees vs 31.5 degrees, t-test, $P < 0.05$) (Fig. 5).

4. Discussion

Our study clearly demonstrates that the VCA measured in uninjured distal radii is significantly greater than the VCA built into modern distal radius volar plates (33 degrees vs 25 degrees), with 96% of cases in our series having a VCA greater than 25 degrees. Furthermore, the lateral VCA is statistically smaller than the middle and medial VCA ($P < 0.0001$) indicating that the distal radial VCA increases from the lateral to the medial sides. Our findings may in part explain the poor contact noted between the distal volar cortex and modern volar plating systems in recent cadaveric studies. Buzell et al. (2008) compare the percentage of plate contact between twenty embalmed distal radii and seven commonly used volar fixed-angle plates [6]. They found that the average values for plate contact only ranged between 3–6%. Stevenson et al. (2009) also noted that there was a trend towards slight under-correction of the volar tilt in comparison to the unaffected side following volar locking plating of distal radius fractures, and this may in part be due to the discrepancy between the plate design and the natural anatomy of the distal radius [19].

Interestingly, we noted that males had a statistically significantly greater VCA than females (33.7 degrees vs 31.5 degrees $P < 0.05$), suggesting that anatomical reduction in male patients may be hindered by the greater angular discrepancy. One solution to the apparent lack of VCA in current plate designs could be to manually pre-bend the plate intra-operatively. A screening lateral radiograph of the contralateral uninjured wrist could provide an assessment of the patient’s native VCA thereby guiding the operating surgeon as to the degree of pre-bending required.

One potential weakness in this study is the relative young age of the patients compared to the more elderly patient who commonly sustain these injuries. It is conceivable that the VCA in more elderly patients maybe different to our study group. However we found no demonstrable correlation between age and VCA in our study (Pearson correlation, $R^2 = 0.18$).

5. Conclusion

Given that the aim of ORIF is anatomical reconstruction, this may be made more difficult using plates that do not have a VCA that accurately reflects the normal distal radial VCA. Although we acknowledge that current volar plate designs can provide an acceptable level of reduction, our data would suggest that these plates could be further optimised to provide a more anatomical reconstruction. Further studies are required to determine if a more anatomical plate VCA results in an improved biomechanical construct leading to better functional clinical outcome.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Sources of funding: None.

References