Distal radius modeling supports contemporary volar distal radius plate design

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Research goal

To model the variability of distal radius anatomy to support the design of a new volar distal radius plating system.

Type of evidence

- Pre-clinical study
- Clinical study
- Registry data
- Literature review

Clinical relevance

- Distal radius fracture is one of the most commonly observed orthopaedic injuries.¹,²
- Treatment via open reduction and volar plating is common. However, this method can be associated with palmar soft-tissue irritation from plate prominence, due to poor implant design or positioning.
- Anatomic CT-based modeling can be used in plate design to improve contouring and sizing. This may reduce postoperative complications such as soft-tissue irritation.

Key result

- The population was stratified according to distal radius width (Figure 1a–b). A mean anatomic model for standard and wide groups was then created using statistical techniques.
- Each model was then used to design the contour, profile and screw trajectories of the D-RAD SMART PACK® Single-Use Volar Distal Radius Plating System (Smith & Nephew) (Figure 1c).

Important considerations

- Cadaver testing validated the fit of this newly developed volar distal radius plating system, confirming the value of the anatomic models.
- Additional research would be needed to confirm the potential benefits of this design for patients.

Figure 1: (a) Distal radius models of standard width (25.6 mm ± 1.17), and (b) wide groups (28.9 mm ± 1.34) (c) Design of new volar distal radius plate (D-RAD Standard Left) using the standard width distal radius model.
Background

Distal radius fractures are among the most commonly observed skeletal injuries, accounting for approximately 15% of all extremity fractures.\textsuperscript{1,2} Moreover, these fractures are associated with significant functional impairment.\textsuperscript{1,2} Volar distal radius plates were introduced to improve fracture reduction, support early postoperative mobilization, and decrease the incidence of soft-tissue irritation.\textsuperscript{3} However, anatomical variation from patient to patient represents a design challenge that has yet to be addressed. Existing implant design is based on limited knowledge about the target anatomy. Anthropomorphic data from the literature is incomplete. Traditionally implant design and fit has been evaluated on a handful of cadaver specimens. However variability of bone shape is difficult to design for using such a limited sample size. Instead, statistical shape analysis techniques can be used to study anatomy diversity in a population\textsuperscript{4}.

Therefore, an analysis was performed to determine if distal radius anatomical variability within a representative population can be effectively modeled, thereby improving the fit and function of new volar distal radius plate designs.

Methods

- Computed tomography (CT) images were produced for 29 human radii (Figure 2a).
- The surface points of each distal radius were modeled to allow for a three-dimensional representation of the anatomy (Figure 2b).
- The width of each distal radius was assessed by measuring the widest anatomical landmark proximal to the watershed line (Figure 3).
- The width distribution of the input population was split into two groups to mimic the sales units of the existing PERI-LOC\textsuperscript{®} Volar Distal Radius implant. The group was split into either standard (N = 22, 76%) or wide (N = 7, 24%) subgroups.
- Each group of models was then used to generate a mean statistical shape model.

Figure 2: (a) Example CT image of one human radius (b) distal part of radius used for model creation.

Figure 3: Distal radius width distribution among the 29 subjects (top); Grouping of distal radius width distributions. (a) Standard: 25.6mm (±1.17); (b) Wide: 28.9 (±1.34) (bottom)
Results

- Analysis suggests that the aforementioned distal radius modeling technique is a valid, accurate representation of the subject population’s anatomy.
- Each model was used to design the contour, profile and screw trajectories of the newly developed standard and wide four-hole volar distal radius plates included in the D-RAD SMART PACK™ System.
  - The contours of the D-RAD SMART PACK Standard and Wide plates conform to the volar distal radius near the watershed line. Distal plate positioning provides support to both the lunate facet and the radial styloid.
  - The D-RAD SMART PACK System allows for both fixed and variable angle screw trajectories through the use of the provided instrumentation.
  - The divergent fixed angle screw trajectories were designed for optimal placement across a population of specimens using the standard and wide models. Key considerations for fixed angle screw trajectory placement were: supporting the lunate facet, capturing radial styloid fragments, and allowing distal plate placement while avoiding screw placement in the radiocarpal joint. Fixed angle screw trajectories are shown (Figure 4).
  - The variable angle trajectory of Variable-Angle Locked Plating (VLP™) allows the surgeon to adapt to individual anatomy and fracture patterns as needed. This VLP technology is the same as used in the PERI-LOC™ VLP systems (Smith & Nephew, Inc., Memphis, TN, USA).
- The accuracy of the distal radius models was verified during cadaveric implantation and fluoroscopic testing (Figure 5), where 29 plates were matched against cadaver specimens to confirm plate fit.
Conclusion

The described distal radius modelling technique has enabled the design of anatomic volar distal radius plates. A morphologic study, cadaveric implantation and fluoroscopic evaluation each showed that the two plate designs (standard and wide) will meet the majority of the population’s anatomical variations. More research is necessary to determine if anatomically-modelled volar distal radius plates can reduce soft tissue irritation.

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References


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