Characterization of the Dorsal Ulnar Corner in Distal Radius Fractures: Implication for Surgical Decision Making

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Introduction

Distal radius fractures are among the most common fractures seen in the upper extremity[1]. Numerous classification schemes have been developed to describe fracture patterns, stability, displacement, mechanism of injury, and help guide appropriate management. The typical fracture pattern contains a subset of the following segments: radial column, dorsal ulnar corner, dorsal wall, volar rim, and free intra-articular fragments[3]. To date, the dorsal ulnar corner has been described anatomically, but its size has not yet been characterized. Knowing intra-articular fragment components and the typical fracture anatomy aids in planning of articular reduction and internal fixation. Numerous distal radius fixation techniques exist, including percutaneous pinning, external fixation, volar and dorsal plating, fragment specific plating, and screw fixation. The benefit of this study will be to better understand the morphology and size of typical distal radius fracture patterns, particularly the dorsal ulnar corner. This will permit further research to improve understanding of how best to capture and secure dorsal ulnar corner fracture fragments, and can lead to more accurate intra-articular fracture models for additional biomechanical studies.

Objectives

- **Explore the use of 3D segmentation software to produce 3D models of intra-articular distal radius fractures using CT scan images.**
- **Extract and characterize the dorsal ulnar corner fracture fragments that are observed in low-energy distal radius fractures in a relatively osteopenic population.**
- **The description of the fragment will include height, width, and depth of each fragment described (descriptive statistics will include mean and standard deviation, normalized to the lunate depth).**

Hypothesis

3D segmentation software can be used to produce a dorsal ulnar corner fragment model that can be analyzed and ultimately direct treatment.

Methods

- The senior authors' patient database was retrospectively analyzed and a study population included those with intra-articular distal radius fractures occurring in a low energy trauma setting, in a relatively osteopenic population (females over the age of 45).
- Twenty preoperative CT scans were loaded and analyzed using the Amira 5.0 3D reconstruction software program to visualize intra-articular fracture patterns and isolate fracture fragments.
- The dorsal ulnar corner fragment was isolated and measured (dorsal surface height and width; articular surface width and depth). Measurement methods were consistent among fragments and determined based upon clinical utility.
- Each measurement was normalized to the patient's lunate depth[2] to control for variability in distal radius sizes.
- Measured dimensions of the dorsal ulnar corner fragment were plotted and compared using mean and standard deviation values.

Discussion

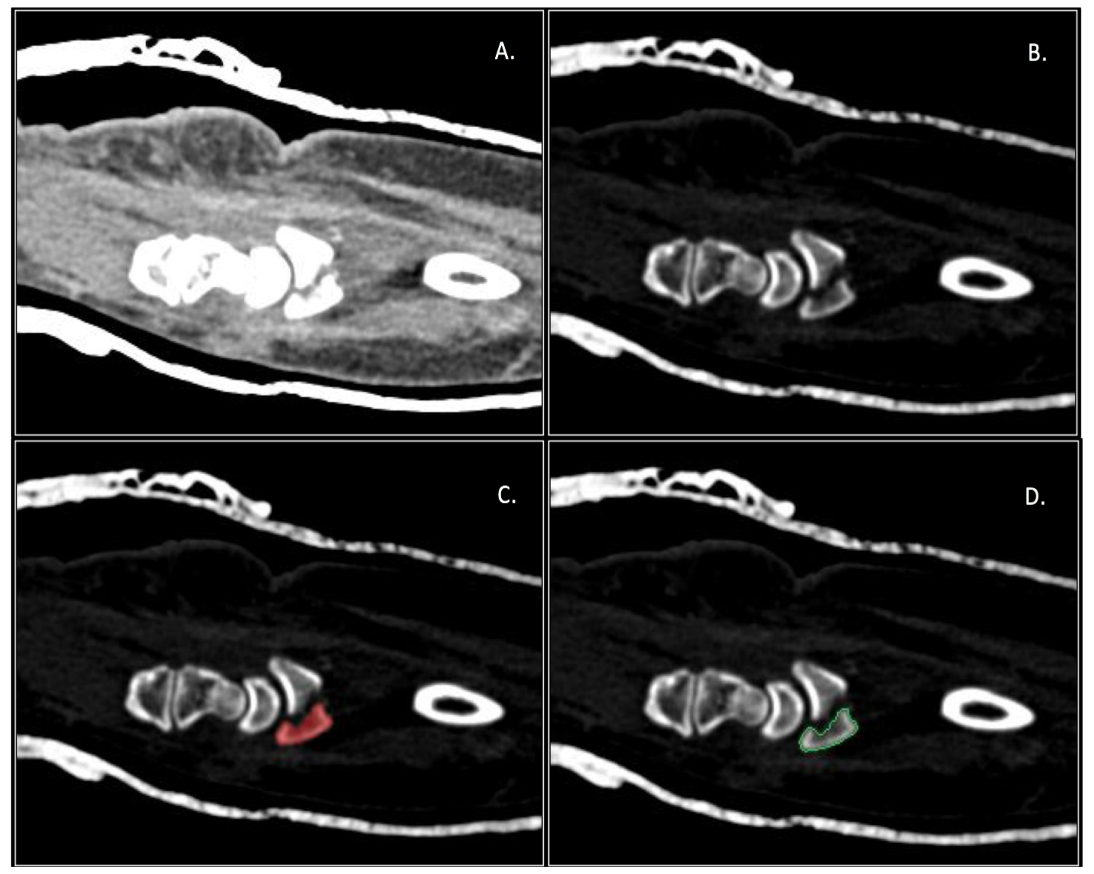
- Dorsal ulnar corner fragment dimensions revealed dorsal surface height (11.28±3.93mm) and width (14.40±4.12mm); articular surface width (7.69±4.29mm) and depth (4.65±2.28mm).
- These measurements were normalized by using the patients' lunate depth measurement (17.55±1.51mm).
- Corrected dorsal surface height (0.83±0.25) and width (0.64±0.21); articular surface width (0.43±0.23) and depth (0.27±0.13) represented as ratios.

Conclusions

- **3D segmentation software is effective in producing 3D distal radius fracture models that can be used for analysis.**
- **The study demonstrated a pattern in dorsal ulnar corner fragment shape, though the study population size should be increased to improve the power of the results.**
- **The data will improve understanding of the morphology and size of the dorsal ulnar corner fracture fragment, which is critical to understanding the optimal method of operative fixation.**
- **This information will also lead to development of more accurate intra-articular fracture models for biomechanical studies.**

Results

Figure 1: Software Segmentation Process (Slice #189)



A) Sagittal *OrthoSlice* of distal radius fracture as raw image.
B) Altered pixilation thresholds, improving tissue density discrepancies.
C) Manual selection of "material" for segmentation (using Amira 5.0 *Brush, Lasso, Threshold, Magic Wand,* or *Blow Tool* applications)
D) Selected data (voxels) assigned to a "material" component of the reconstruction.

Figure 2: Slice Material Assignment and Build-up [Slices #189(A)-194(F)] Process. Assigned purple "Inside" material, green "UC" material (Ulnar Corner).

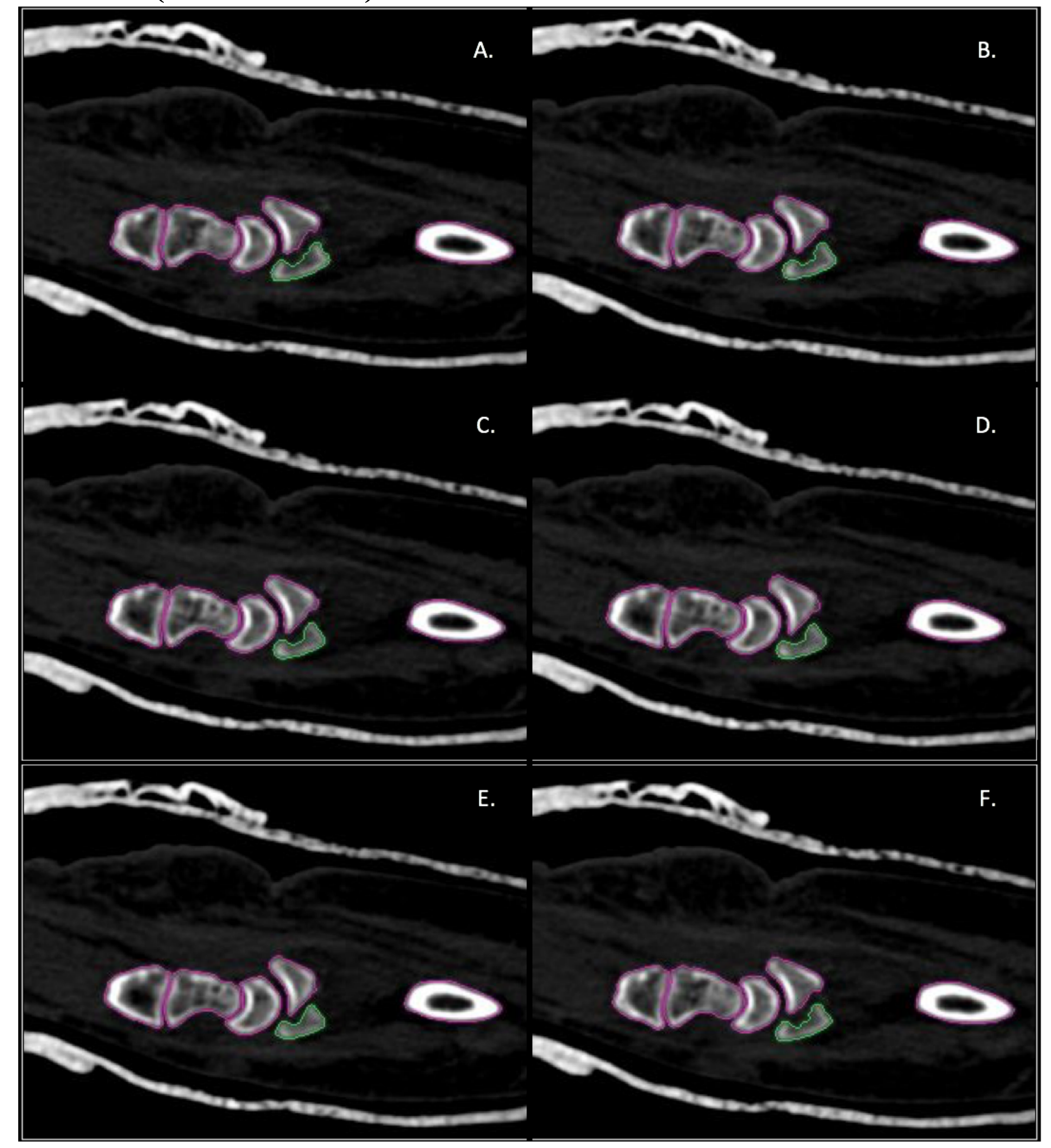
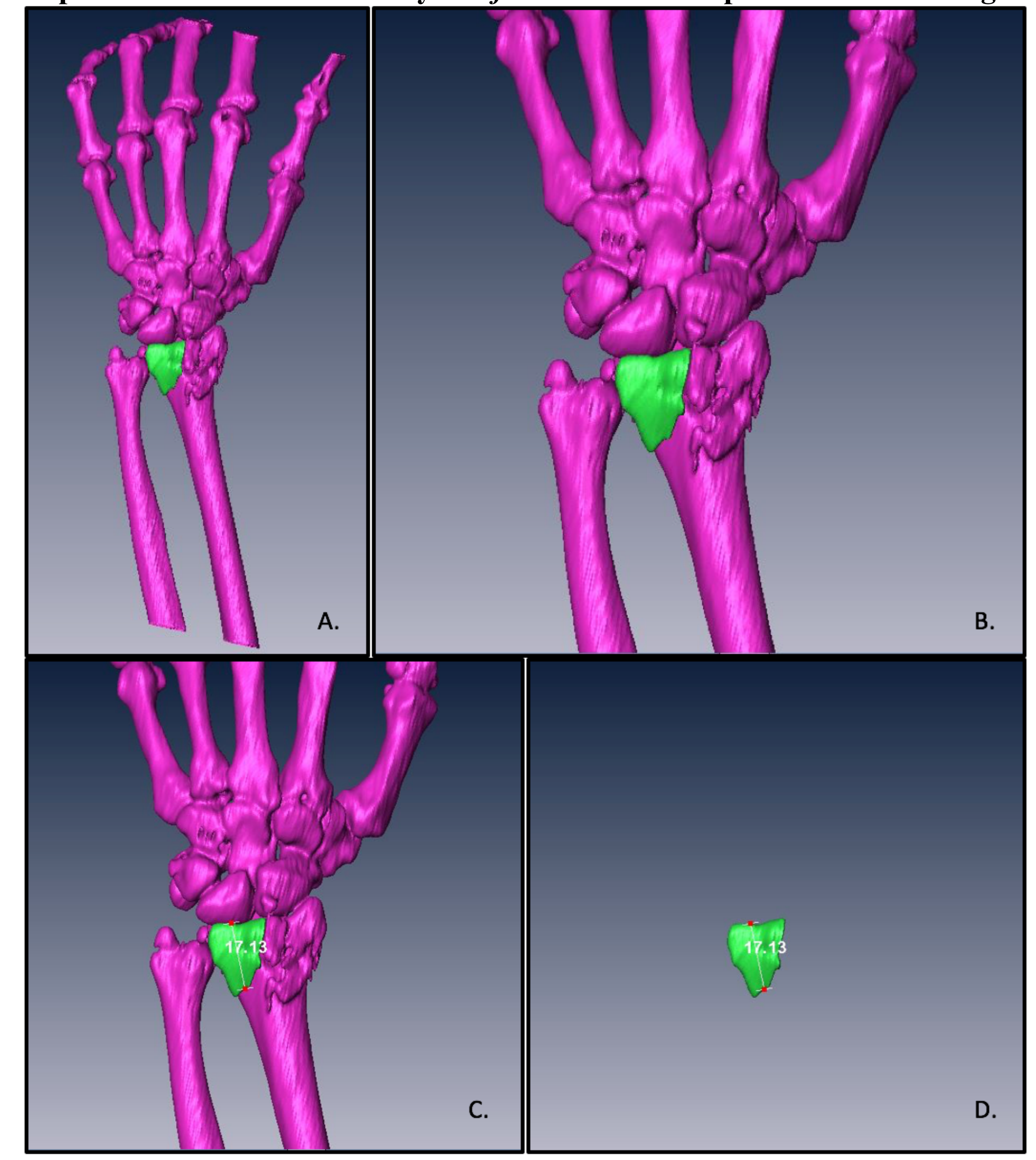


Figure 3: 3D Reconstruction. Segmented labels were computed by the *SurfaceGen* application ("unconstrained smoothing" feature and data interpolation) to produce a model representative of the anatomy. *SurfaceView* feature produced a 3D image.



A) Zoomed out dorsal view. Green material assigned to the dorsal ulnar corner.
B) Amira 5.0 allows for zooming in, out, and rotation.
C) When toggled on the *Orthographic* viewing module, measurements can be made.
D) Fragment "material" components can be extracted from the rest of the field, manipulated/rotated and measured.

Figure 4: Fragment Measurement. The following methods were used to collect measurements of the dorsal median height (A), dorsal median width (B), articular surface depth (C), and articular surface width (D). Figure E shows the dorsal ulnar corner fragment from different angles and with the surrounding bony structures from the axial view.

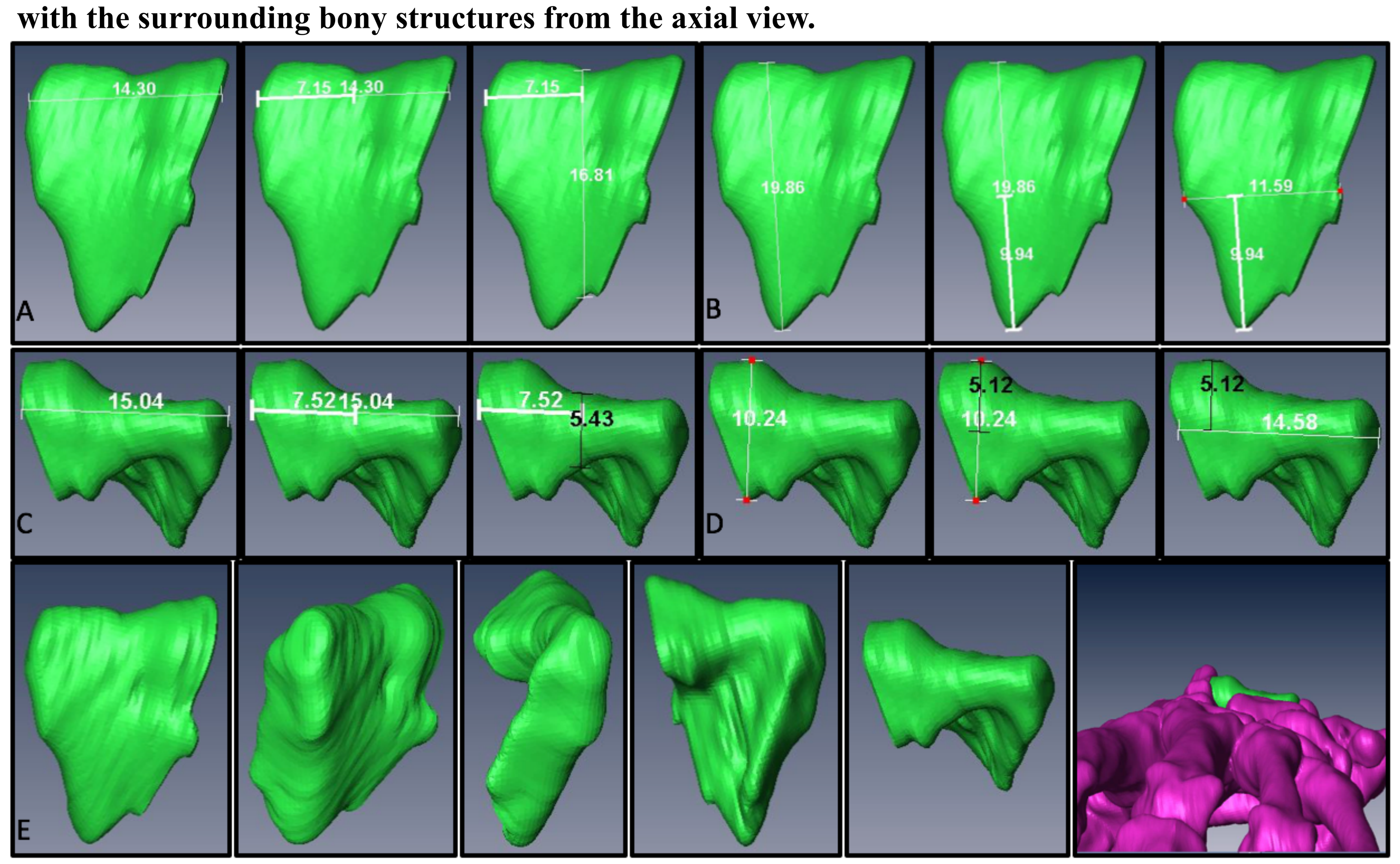


Figure 5: Lunate Depth Measurement[2]. Corrects for patient size while on *OrthoSlice* mode.

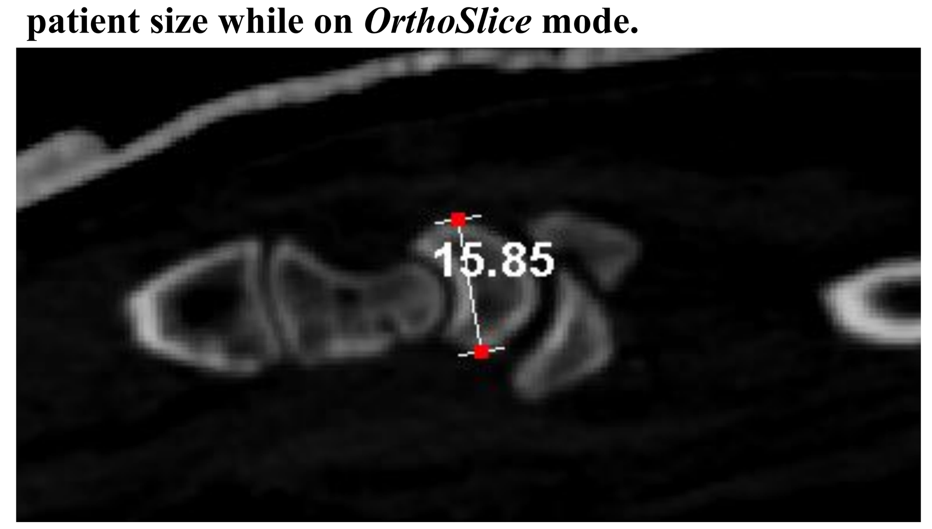
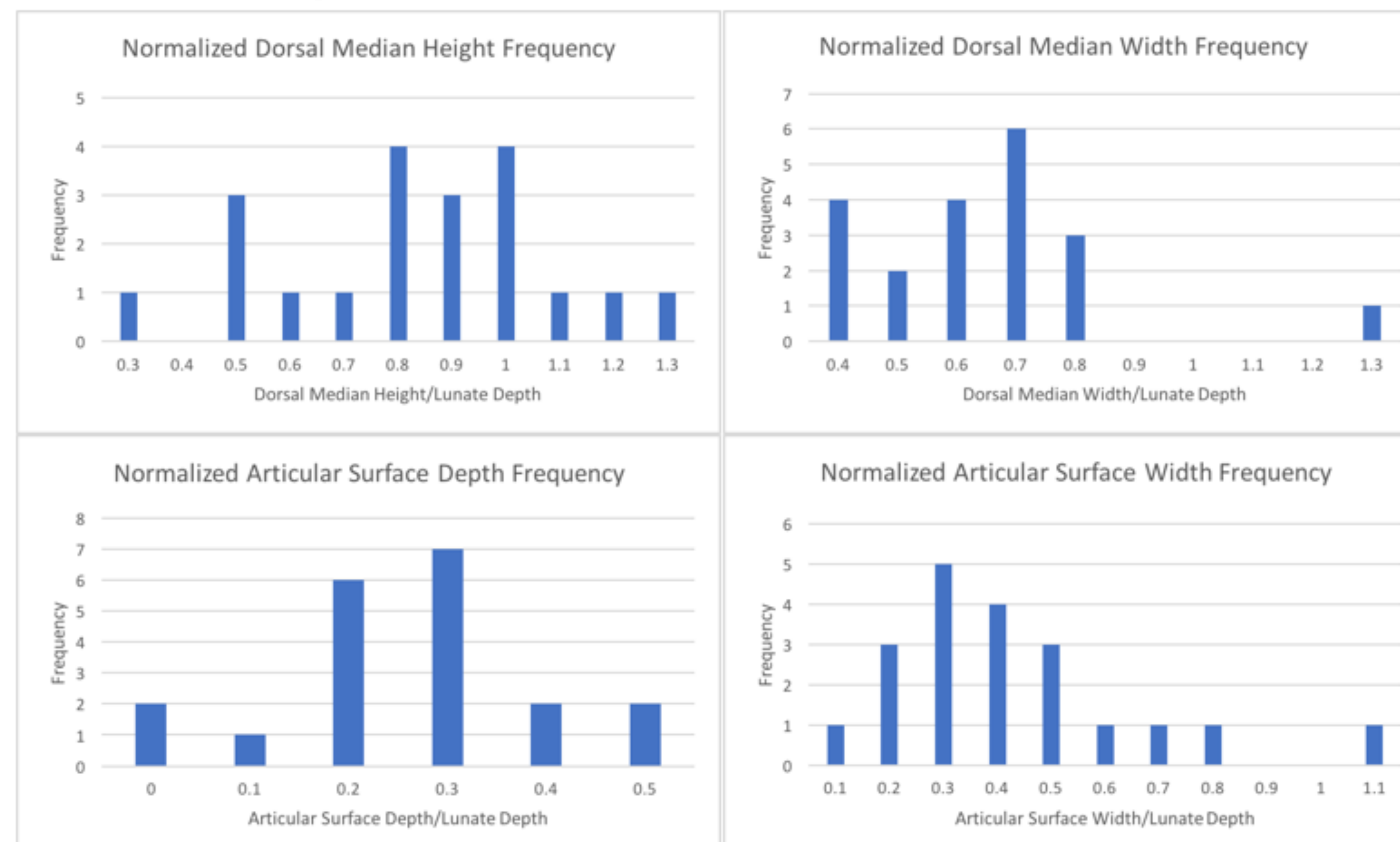


Figure 6: Normalized Dorsal Ulnar Corner Fragment Dimension Measurement Frequencies. Values are presented as a ratio of measurements to lunate depth.



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2. Ljungquist, K. L., et al. (2015). "Predicting a Safe Screw Length for Volar Plate Fixation of Distal Radius Fractures: Lunate Depth as a Marker for Distal Radius Depth." The Journal of Hand Surgery 40(5): 940-944.
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