KINEMATIC AND MECHANICAL CHANGES IN THE DISTAL RADIOULNAR JOINT (DRUJ) OF PATIENTS WITH MALUNITED DISTAL RADIUS FRACTURES

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INTRODUCTION

Kinematic (e.g. rigid body motion) and mechanical (e.g. joint contact area and ligament strains) changes are considered to be etiological factors in arthritis, but accurate measurements of these factors *in vivo* is technically challenging. Using markerless bone registration [1], we recently demonstrated that in patients with no ulnar pathology, distal radius malunion does not alter the kinematics of the radius during pronosupination, and does not create a bony block to forearm rotation [2]. Nevertheless, in these patients, forearm rotation can be limited or painful, and they often develop arthritis of the distal radioulnar joint (DRUJ). Apparently, altered kinematics of the radius is not a good predictor of the progression of this disease.

In this study, we hypothesized that malunion of the distal radius alters the mechanics of the DRUJ, which might ultimately affect long-term clinical outcome. To test this hypothesis, we developed a novel technique for estimating joint contact area and soft tissue constraints from CT volume images. In particular, we estimated changes in the articulation at the DRUJ (location and size of bony contact), and in the lengths of the dorsal and volar radioulnar ligaments.

METHODS

Following IRB approval, CT scans were performed on both wrists of nine volunteers with unilateral distal radius fractures (3M, 6F, age 55 ± 15.4 yrs). Dorsal angulation and radial shortening of the injured wrists averaged 20.9 ± 5.8 degrees and 4 ± 3 mm, respectively. Scans were taken with the wrists in neutral, and in multiple positions of pronation and supination. Cortical bone surfaces and the kinematics of radii with respect to the ulnae were calculated using markerless bone registration techniques [1]. Then parametric (manifold surfaces) and implicit (scalar distance fields) representations of bones were used to compute inter-bone distance fields. From these distance fields we determined joint contact areas and ligament lengths.

Contact area was defined as the area on the surface of the ulna that was 5 mm or less from the surface of the radius. The location of the centroid of the contact area was described with respect to the long axis of the ulna, with the origin at the ulnocarpal surface, positive proximally. Dorsal and volar radioulnar ligament path lengths were defined as the length of the shortest paths between the radial and ulnar insertion points, constrained to avoid bone penetration. Ligament deflection was defined as the maximum distance from this path to the straight line between insertion points

The significance of the changes in the mechanics of the DRUJ were assessed by comparing these variables in the malunited and uninjured wrists using a generalized linear model, which controlled for forearm rotation angle (–60° to 60°) and made comparisons within subjects. P values = 0.05 were considered to be statistically significant.

RESULTS

Contact area in the malunited wrists was smaller than that of the uninjured wrists at all positoons of pronosupination (Fig. 1). Overall, the contact area on the ulna was a mean of 56 mm^2 (Standard Error (SE) 4.0 mm^2) smaller in the malunited wrists than in the contralateral uninjured controls (P <0.01), and its centroid was located 1.3 mm (SE 0.1 mm) more proximally (P <0.01). Contact area and location did not change significantly with forearm rotation angle.

Radioulnar ligament length varied as a function of ligament, injury and forearm rotation. Briefly, the doersal radioulnar ligament: 1) was a mean of 3.9 mm (SE 0.3 mm) longer in the malunited wrists than in the uninjured wrists (Fig. 2; P <0.01); 2) increased in length during pronosupination at the same rate in both the malunited and uninjured wrists (Fig. 2; P <0.01), and; 3) "wrapped" around the head of the ulna in all nine malunited fractures (with an average deflection of 0.5 mm (SE 0.5 mm)), but in only two of the uninjured wrists. In contrast, the volar radioulnar ligament was: 1) essentially the same length in the uninjured and malunited wrists; 2) longest when the wrist was in neutral.

Fig 1. Ulna contact area (defined as the bony surface area on the ulna within 5 mm of the bony surface of the radius) was significantly less in the malunited wrist at forearm positions from –60° to 60°.

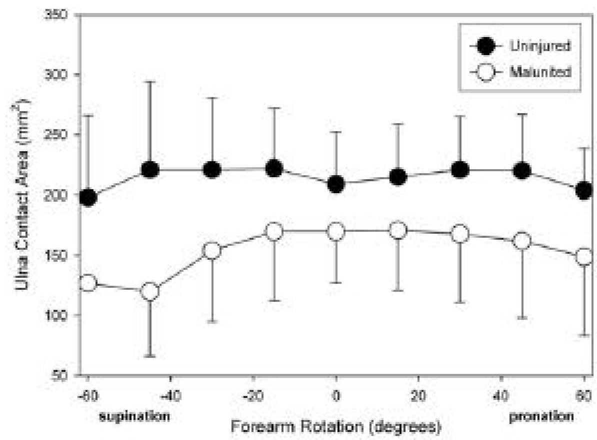
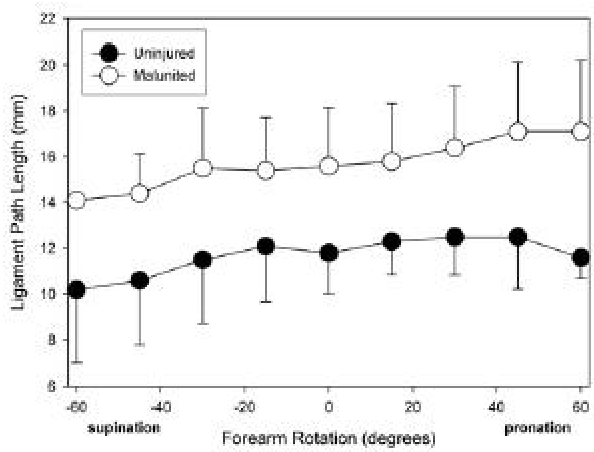


Fig 2. Dorsal radioulnar ligament length (defined by the path between insertions constrained to avoid bone penetration) was significantly shorter in the malunited wrists at forearm positions from –60° to 60°.



DISCUSSION

In this study we developed novel techniques to quantify joint mechanics. Using these techniques we explored DRUJ articulations in a group of clinical patients with unilateral malunited distal radius fractures and found significant changes in the mechanics of the joint despite normal rigid body kinematics of the radius [2]. These findings lend further support to the concept that soft tissues, rather than bony impingement, can limit forearm rotation in certain patients with malunited distal radial fractures. These findings also document changes in joint mechanics that may influence long-term clinical outcomes.

REFERENCES

1. Crisco et al., J Ortho Res, 1999.
2. Moore et al, J Hand Surg, 2002

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