CHANGES IN WRIST MOMENT ARMS OF THE FIRST DORSAL EXTENSOR COMPARTMENT FOLLOWING SIMPLE DISTAL RADIUS MALUNIONS

[1]Gregory L. Scallon, [3,4]Michael S. Bednar, [5]Amy L. Ladd, and [1,2,4] Wendy M. Murray
Depts. of [1]Biomedical Engineering and [2]PM&R, Northwestern University; [3]Dept. of Orthopaedic Surgery and Rehabilitation, Loyola University; [4]Edward Hines Jr. VA Medical Center; [5]Dept. of Orthopaedic Surgery, Stanford University
email: w-murray@northwestern.edu

INTRODUCTION

Distal radius fractures comprise over 10% of classified fractures seen in US and European Emergency Departments [1]. If all displaced fractures were treated exclusively with closed reduction (non-invasive realignment), it is postulated that 60% would later fuse into the deformed, unreduced state, yielding a malunion [2]. Even with current management techniques, 27% of these displaced fractures lose their reduction [3]. Thus, open reduction (invasive realignment) or even osteotomy (surgically fracturing the fused bone) is frequently warranted to correct deformity. Increasing anatomical deformity in a distal radius malunion is associated with loss of grip strength, range of motion, and unfavorable cosmetic assessment [4]. However, the severity of the deformity that requires surgical intervention is not well defined.

This work aims to improve understanding of the role biomechanics plays in decreased function following distal radius malunions. Significant changes in wrist moment arms of muscles of the first dorsal extensor compartment have been observed in a cadaver study that simulated complex malunions involving significant dorsal angulation, radial inclination, and radial shortening [5]. We simulated a range of simpler distal radius malunions in order to elucidate how malunion severity influences the wrist moment arms of the muscles of the first dorsal extensor compartment.

METHODS

We simulated a broad range of simple distal radius malunions using a biomechanical model of the upper limb [6]. A transverse cut was made 3.3 cm proximal to the radial styloid process, creating an extra-articular "fracture" in the radius. Three degrees of freedom—dorsal angulation, radial inclination, and radial shortening—were introduced by a fracture "joint" describing the rigid body transformation from the proximal radius to the distal fracture segment (Fig. 1). The "range of motion" for each degree of freedom ranged from the normal anatomy of the distal radius to 14.1° radial inclination, 25.9° dorsal anguation, and 7.2 mm radial shortening, respectively. Positioning all three degrees of freedom at their extreme values simulated the complex malunion evaluated in the previous cadaver study [5].

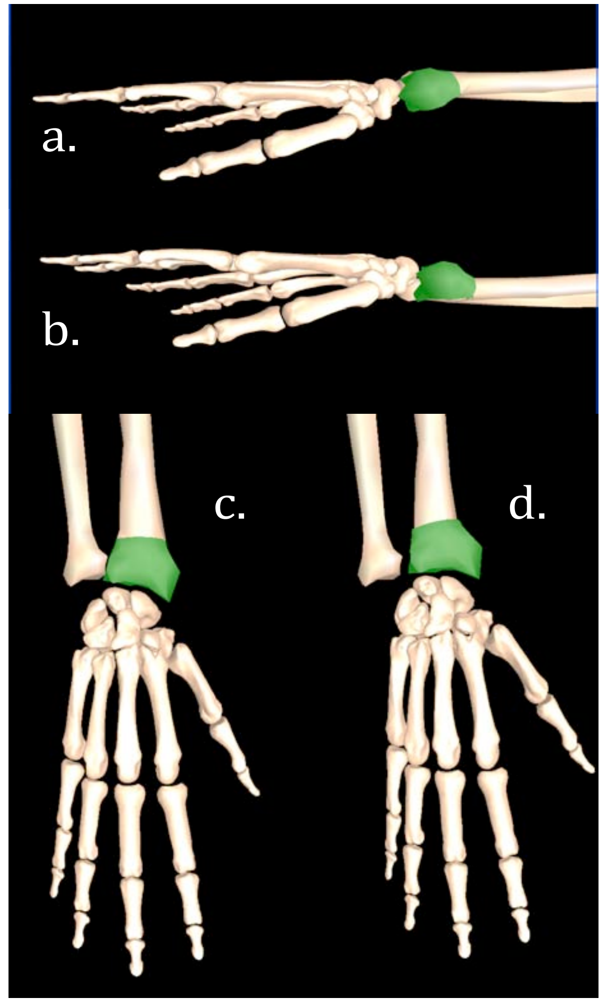

Figure 1. Model used in normal wrist configuration (a,c) and with 25.9° of dorsal angulation (b) and 14.1 ° of radial inclination (d).

Flexion and deviation moment arms of the muscles of the first dorsal extensor compartment, extensor pollicis brevis (EPB) and abductor pollicis longus (APL) were estimated at neutral flexion and deviation. The change in moment arm produced by each simple malunion was normalized by the change in moment arm caused by the complex malunion.

RESULTS AND DISCUSSION

Overall, isolated radial inclination had a more substantial effect on wrist flexion moment arms than deviation moment arms (Fig. 2). Radial inclination of 14.1° decreased flexion moment arm of EPB by 74.8% of the decrease caused by the complex malunion. For the APL, radial inclination of 14.1° decreased flexion moment arm 122% of that caused by the complex malunion.

In contrast, isolated dorsal angulation had a greater effect on deviation moment arms than flexion moment arms. Dorsal angulation of 25.9° increased the wrist deviation moment arm of EPB by 123% of the increase caused by the complex malunion. For the APL, dorsal angulation of 25.9° increased flexion moment arm 98.9% of that caused by the complex malunion.

As secondary effects, radial inclination increased deviation moment arms of both muscles (< 50% of complex malunion, Fig. 2B), and dorsal angulation decreased flexion moment arms of both muscles (< 50%). There were no observed effects of radial shortening on EPB or APL wrist moment arms.

To validate the simulations, changes in flexion and deviation moment arms of the EPB and APL were compared to the anatomical model of the complex malunion [5]. The simulated complex malunion produced the trends described in the cadaver study.

CONCLUSIONS

Both radial inclination and dorsal angulation decreased flexion moment arms and increased deviation moment arms. However, the changes were not additive and, at the extreme values, isolated radial inclination and dorsal angulation caused greater moment arm changes than the complex malunion. These results suggest that isolated malunion deformities may have comparable or more pronounced effects on the mechanical actions of the first dorsal extensor compartment than combinations of these deformities. Thus, surgical intervention may be necessary in malunions that exhibit only one degree of radiographic deformity.

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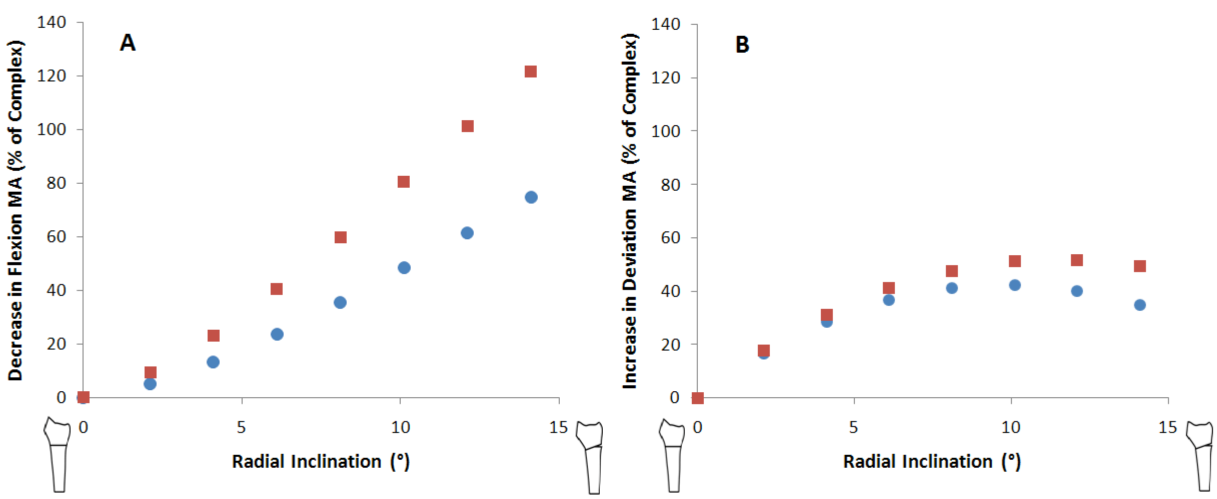

Figure 2. Effects of isolated radial inclination on muscle moment arms of the first dorsal extensor compartment. (A) Decrease in flexion moment arms for the EPB (blue circles) and APL (red squares). Increase in deviation moment arms (B). Zero degrees represented no deformity.