Carpal Joint Malalignment with Distal Radius Malunion and Factors in Correction after Distal Radius Osteotomy

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INTRODUCTION:

Distal radius malunions are challenging. Currently, there are no recommendations on when to correct for distal radius malunions, whether severity of initial injury correlates with radiographic outcomes, or how different radiocarpal and midcarpal adaption patterns relate to radiographic outcomes. The purpose of this study is to assess the effects of distal radius corrective osteotomy on preoperative carpal joint malalignment resulting from distal radius malunion, and correlate injury severity and osteotomy timing with radiographic outcomes.

METHODS:

A retrospective review of patients who undergo a corrective osteotomy for a distal radius malunion with a minimum clinical and radiographic follow up of 12-weeks was performed. Twenty-seven fractures in twenty-six patients required osteotomy for a dorsal distal radius malunion. Clinical outcomes included time from injury to osteotomy and time to union. Preoperative and postoperative radiographic outcomes included measuring radial inclination, radial height, ulnar variance, and volar tilt. Assessment for carpal maladaptive patterns were performed using the radiolunate angle(RLA), radioscaphoid angle(RSA), and capitolunate angle(CLA). To better understand maladaptive patterns, Gupta et al., (2002) assessed the "effective radiolunate flexion"(ERLF) angle which examines the relationship between the radius and lunate. Patients with an ERLF angle >25° are grouped into the radiocarpal(RC) maladaptive patterns, whereas patients with an ERLF angle <25° are grouped into the midcarpal(MC) pattern. For comparison purposes, a relative-radiolunate angle(RRLA) was constructed by measuring the angle between longitudinal axis of the distal articular surface of the radius to the longitudinal axis of the lunate. Statistical analysis was used to determine significance.

RESULTS:

Twenty-seven radii were available for analysis at a mean of 68 weeks and age of 54 years. The mean time from injury to distal radius corrective osteotomy was 49 weeks. Mean time to union after corrective osteotomy was 15 weeks.

Using the ERLF classification system, 16 patients (59%) were grouped into the type I MC adaptation, and 11 patients (41%) grouped into type II RC adaptation. **Table 1** shows the radiographic outcomes of both groups.

Improvements in all radiographic parameters were seen in the MC group, except for RRLA ($p > 0.05$). The mean improvements were 4.6 mm in radial height, 8.8° in radial inclination, -1.5 mm in ulnar variance, 19.0° in volar tilt, 11.0° in RLA, 7.0° in RSA, -6.4° in CLA, and -7.9° in ERLF ($p < 0.05$). Of the 16 patients classified into the MC group, one displayed both MC and RC adaptations while one showed no carpal adaptations.

Improvements in all radiographic parameters were seen in the RC group, except for RLA and CLA ($p > 0.05$). The mean improvements were 5.3 mm in radial height, 12.2° in radial inclination, -3.3 mm in ulnar variance, 31° in volar tilt, 7.2° in RSA, -23.7° in ERLF, -10.5° in RRLA ($p < 0.05$). Of the 11 patients classified in the RC group, two displayed isolated RC adaptations while nine exhibited both RC and MC adaptations.

Postoperative ERLF was more difficult to correct for the RC pattern versus the MC pattern. The RRLA reinforced the correct categorization the MC and RC patterns by showing an extended lunate relative to the distal radius in the MC group, and a flexed lunate relative to the distal radius in the RC group.

Initial severity of injury correlated with ability to correct ERLF, but not RLA, CLA, or RRLA ($p > 0.05$). Specifically, preop radial height, radial tilt, and ulnar variance had a correlation of -0.41, 0.39, and 0.40, respectively ($p < 0.05$) to postop ERLF. Multiple linear regression revealed that initial severity was not a significant predictor of postop ERLF ($p > 0.05$).

Time from injury to corrective osteotomy correlated with the ability to correct for RLA with a correlation coefficient of 0.47($p < 0.05$). It was more difficult to correct for RLA with increased time from injury to osteotomy, especially beyond 40 weeks ($p < 0.05$).

DISCUSSION AND CONCLUSION:

ERLF classification system assigns patients to their respective maladaptation: RC and MC . However, RC patterns are not isolated in nature, but often occurs alongside MC patterns. It was previously thought that these carpal adaptations occur exclusively, but those showing a RC pattern, may have some form of MC adaptation as well. Following a dorsal radius malunion, the lunate flexes on the radius to properly realign itself, but if not adequately achieved, the next link in the kinetic chain, the capitate, begins flexing on the lunate to compensate. A similar classification system we used, the RRLA, is just as effective and easier compared to the ERLF system. Our findings show that when the preop-RRLA is negative, denoting an extended lunate in relation to the distal radius, patients exhibited a MC pattern. When the preop-RRLA is positive, patients showed a RC pattern. The RRLA may be useful for a quick analysis of potential maladaptive patterns seen in dorsal distal radius fractures.

Severity of the initial fracture correlates but does not predict the ability to correct radiographic parameters in dorsal bending malunions. Additionally, timing of osteotomy is important and does matter, with 40 weeks being the closest conversion point ($p = 0.03$) after which there is greater difficulty in getting the adaptive changes to correct to normal radiographic parameters. Early correction of distal radial malunions is recommended, especially in patients with radiocarpal malalignment due to the greater difficulty in achieving baseline values. There should be added emphasis on early correction and patient counseling that it represents a scenario where correction will likely be more challenging, albeit with unclear knowledge of the clinical implications of ongoing radiocarpal adaptive change.

Table 1: Dorsal Bending Radiographic Outcomes: Radiocarpal and Midcarpal

		Midcarpal(n=16)			Radiocarpal(n=11)		
Parameters	Normal Value (SD)	Preop (SD)	Postop (SD)	P-Value	Preop (SD)	Postop (SD)	P-Value
Mean Radial Height(mm)	11 (3)	3.9 (5.4)	8.5(3.9)	p < 0.0001*	4.0 (3.6)	9.3 (3.1)	p < 0.00009*
Radial Inclination	22° (3°)	11.9° (6.4)	20.7° (7.0)	p < 0.0001*	11.2° (6.3)	23.4° (4.6)	p < 0.0001*
Ulnar Variance(mm)	0.9 (4)	2.9° (3.1)	1.4° (1.8)	p < .008*	5.3° (3.8)	2.0 (2.3)	P < .003*
Volar Tilt	11° (6°)	- 18.0° (6.9)	1.0° (4.6)	p < 0.0001*	- 30.6° (14.0)	0.4° (4.7)	p < 0.0001*
Radiolunate Angle	10° (6°)	-20.8° (10.2)	-9.8° (8.0)	p < 0.0002*	-7.2° (12.8)	0.6° (7.0)	p = 0.067
Radioscaphoid Angle	60° (4°)	48.1° (10.2)	55.1° (7.1)	p < 0.004*	48.4° (5.9)	55.6° (3.7)	p < 0.002*
Capitolunate Angle	-12° (2°)	6.5(12.9)	0.04 (-13.4)	p < 0.009*	2.5(9.3)	-1.1(10.5)	p = 0.42
Effective Radiolunate Flexion (ERLF)	0°	8.2° (11.2)	0.3° (6.2)	p < 0.015*	34.3° (10.7)	10.6° (6.8)	p < 0.0001*
Relative - Radiolunate Angle	0	-4.7(11.6)	-7.2° (10.2°)	p = 0.56	18.0(10.1)	7.5° (10.4°)	p < 0.04*

Values are given as the mean, parentheses as standard deviations

*Statistically significant p-value < 0.05