Supplementary Fixation Improves Stability of Intraarticular Distal Radius Fractures Managed with a Spanning Plate

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INTRODUCTION:

Prior studies evaluating distal radius fractures treated through dorsal spanning bridge plates with early crutch or walker weight bearing in the polytrauma and elderly patients have been inconclusive. These studies evaluate extra-articular fracture patterns with 5mm displacement at load to failure and they do not evaluate the role supplementary fixation may play. Our hypothesis was that supplementary fixation with a spanning dorsal bridge plate for an intraarticular wrist fracture would decrease the displacement of individual articular pieces with cyclic axial loading and allow for walker and/or crutch weight bearing.

METHODS:

30 cadaveric forearms were matched into 3 cohorts, controlling for age, sex, laterality, and bone mineral density (Table 1). An intraarticular fracture model was created with osteotomy blocks 1cm proximal to the lunate facet articular surface and between the radial styloid and lunate facet. The specimens were fixed with 3 techniques (Figure 1). Cohort A was fixed with a dorsal spanning plate. Cohort B was fixed with a dorsal spanning plate and two 1.6mm k-wires. Cohort C was fixed with a dorsal spanning plate and a radial pin plate (Trimed, Santa Clarita CA) mirroring the k-wire trajectories in Cohort B. Specimens were axially loaded cyclically with escalating weights of 2kg, 5kg, 22%BW (body weight) for walker WB (weight bearing), 30%BW, 40%BW, and 50%BW for crutch WB for 100 cycles and 1000 cycles at 50%BW (Figure 2). Failure measured via a high-resolution camera was defined as 2mm displacement of any of the articular fracture pieces from each other, including radial styloid-lunate facet, radial styloid-radial shaft, and lunate facet-radial shaft displacement.

RESULTS:

In Cohort A, 8 specimens failed the loading protocol, with 2 failing at walker WB and 6 failing at crutch WB. In Cohort B, 5 of the specimens failed with 1 failing at walker WB and 4 failing at crutch WB. In Cohort C, 3 of the specimens failed, all at cyclic walker WB and none cyclic crutch WB. In terms of overall failure, Cohort A had significant more failure than Cohort C (P<0.05) (Table 2). No specimens in any cohort failed at 2kg or 5kg weights, but Cohort A had significant more displacement at these weights compared to Cohort B. Both Cohort A and Cohort B had significant more displacement at crutch weight bearing compared to Cohort C (Table 3). The supplementary fixation combined group of Cohort B and C had significantly lower displacement at crutch weight bearing compared to Cohort A in all gaps, most notably between the radial styloid and lunate fossa (Table 4, 1.00mm vs 2.41mm, p= 0.0003). Survival curves demonstrated the fixation cohort to have longer survival than the non-fixation group.

DISCUSSION AND CONCLUSION:

All 30 wrists sustained cyclic weight bearing at 2kg and 5kg weights without significant displacement and these weights should be considered safe in the early postop course. For weight bearing loads, there was significantly less displacement and less failure for cyclic loading at crutch and walker weight bearing of intraarticular distal radius fractures treated with a spanning dorsal bridge plate and supplementary fixation. While the radial pin plate had higher survival than K-wires alone, this was not statistically significant. More importantly our model showed that either type of fixation was significantly superior to the no fixation group. When considering early WB for intraarticular distal radius fracture in the polytrauma patient treated with a spanning dorsal bridge plate, supplementary fixation should be considered as an augmentation to prevent fracture displacement.

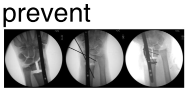

Figure 1. Fluoroscopy images of Cohort A (Left), Cohort B (Middle), and Cohort C (Right).

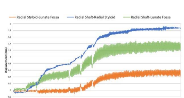

Figure 2. Example data showing the displacement profile of Cohort B8 specimen.

Characteristic	Overall	Cohort A	Cohort B	Cohort C	P
Female sex, n (%)	20 (66.67)	7 (70.0)	6 (60.0)	7 (70.0)	0.99
Right laterality, n (%)	12 (40.0)	6 (60.0)	5 (50.0)	1 (10.0)	0.07
Age (years), Mean (SD)	73.41 (13.93)	73.00 (8.97)	75.11 (12.14)	72.30 (19.70)	0.91
Weight (pounds), Mean (SD)	135.40 (38.77)	133.40 (45.93)	138.80 (34.68)	134.00 (38.88)	0.95
Capitate HU, Mean (SD)	658 (93)	662 (85)	698 (109)	613 (85)	0.47
Distal Ulna HU, Mean (SD)	322 (101)	388 (93)	311 (117)	268 (94)	0.34

Table 1. Specimen Characteristics by Cohort.

Failure Type	Cohort A N=10 n (%)	Cohort B N=10 n (%)	Cohort C N=10 n (%)
Overall			
22% body weight (Walker WB)	2 (20%)	1 (10%)	3 (30%)
30% body weight	4 (40%)	2 (20%)	3 (30%)
40% body weight	7 (70%)†	2 (20%)	3 (30%)
50% body weight (Crutch WB)	8 (80%)*	5 (50%)	3 (30%)

* p<0.05 for comparisons to Cohort C
† p<0.05 for comparisons to Cohort B
Table 3. Failure Rates by Cohort.

Outcome	Cohort A Mean (95% CI)	Cohort B Mean (95% CI)	Cohort C Mean (95% CI)
Radial Shaft-Radial Styloid			
2 kg	-0.13 (-0.18, -0.08)†	-0.06 (-0.11, -0.02)	-0.15 (-0.28, -0.02)
5 kg	-0.32 (-0.46, -0.19)†	-0.13 (-0.21, -0.04)	-0.21 (-0.33, -0.09)
22% body weight	-0.70 (-0.92, -0.48)	-0.58 (-0.97, -0.19)	-0.68 (-1.17, -0.18)
30% body weight	-0.94 (-1.28, -0.59)	-0.97 (-1.47, -0.46)	-0.82 (-1.40, -0.24)
40% body weight	-1.13 (-1.46, -0.81)	-1.15 (-1.59, -0.72)	-0.68 (-1.01, -0.35)
50% body weight	-1.56 (-1.87, -1.25)*	-1.61 (-2.21, -1.02)*	-0.71 (-1.03, -0.39)
Radial Shaft-Lunate Fossa			
2 kg	-0.21 (-0.29, -0.14)†	-0.08 (-0.12, -0.05)	-0.17 (-0.31, -0.03)
5 kg	-0.54 (-0.67, -0.40)†*	-0.17 (-0.25, -0.09)	-0.23 (-0.37, -0.10)
22% body weight	-1.00 (-1.21, -0.79)	-0.66 (-1.03, -0.29)	-0.73 (-1.11, -0.35)
30% body weight	-1.18 (-1.41, -0.95)	-0.89 (-1.36, -0.67)	-0.98 (-1.45, -0.52)
40% body weight	-1.37 (-1.66, -1.08)	-0.99 (-1.31, -0.67)	-0.95 (-1.41, -0.50)
50% body weight	-1.79 (-2.47, -1.10)*	-1.30 (-1.71, -0.88)	-0.97 (-1.26, -0.67)
Radial Styloid-Lunate Fossa			
2 kg	0.20 (0.10, 0.31)†	0.09 (0.06, 0.12)	0.11 (0.07, 0.16)
5 kg	0.65 (0.39, 0.90)†	0.15 (0.10, 0.20)	0.33 (0.00, 0.66)
22% body weight	1.53 (0.98, 2.09)	1.00 (0.38, 1.61)	1.09 (0.25, 1.92)
30% body weight	1.82 (1.17, 2.48)	1.21 (0.50, 1.92)	1.47 (0.39, 2.55)
40% body weight	2.16 (1.46, 2.86)†	1.22 (0.74, 1.71)	1.51 (0.15, 2.88)
50% body weight	2.47 (1.81, 3.13)†*	1.46 (1.01, 1.92)	1.21 (0.54, 1.87)

* p<0.05 for comparisons to Cohort C † p<0.05 for comparisons to Cohort B
Table 3. Estimated marginal means and corresponding 95% confidence intervals for gap displacement by study cohort.

Failure Type	Cohort A N=10 n (%)	Cohort B N=10 n (%)	Cohort C N=10 n (%)
Overall			
22% body weight (Walker WB)	2 (20%)	1 (10%)	3 (30%)
30% body weight	4 (40%)	2 (20%)	3 (30%)
40% body weight	7 (70%)†	2 (20%)	3 (30%)
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* p<0.05 for comparisons to Cohort C † p<0.05 for comparisons to Cohort B
Table 4. Failure Rates by Cohort.