Loss of Reduction in Pediatric Distal Radius Fractures: Risk Factors from a Prospective Multicenter Registry

Apurva Shah[1], Zoe Elizabeth Belardo, Mark Leland Miller[2], Michael C Willey[3], Susan T Mahan[4], Divya Talwar, Donald S Bae[5]
[1]Children's Hospital of Philadelphia, [2]Washington University Orthopaedics, [3]University Of Iowa Hospitals, [4]Children's Ortho Surg Foundation, [5]Children's Hosp Boston

INTRODUCTION:

Distal radius fractures account for up to 30% of all fractures in the pediatric population. Previous epidemiological studies have shown about one third of pediatric distal radius fractures undergo closed reduction. Rates of loss of reduction, or redisplacement following closed reduction, are variably reported, with the current literature predominated by retrospective and single-center investigations. The purpose of this study was to report the rate and risk factors for loss of reduction of pediatric distal radius fractures from a large prospective multicenter cohort. We hypothesized that fractures with increased translation and angulation at the time of injury would be more likely to lose reduction and that older children would more frequently undergo secondary procedures including surgery.

METHODS:

This work derives from the Pediatric Distal Radius Fracture (PDRF) Registry, a longitudinal database formed by 4 tertiary referral children's hospitals with the mission of improving value-based care for distal radius fractures in children. The PDRF Registry was queried for children aged 4-18 years old undergoing closed reduction for a displaced distal radius fracture. Children with open fractures or torus fractures were excluded.

The primary outcome of interest was radiographic loss of reduction (LOR). LOR was defined as any change in angulation ≥10 degrees or an increase in translation greater than 50% of the radial width in any plane. Children were only considered eligible for radiographic analysis if they had coronal and sagittal plane radiographs collected pre-reduction, immediately post-reduction, and out to 4 weeks post-reduction. The secondary outcome of interest was need for a secondary procedure, including repeat closed reduction or surgical treatment. Demographic, clinical, and radiographic variables were analyzed; bivariate analysis and multivariate logistic regressions were performed.

RESULTS:

In total, 655 children (69% male) were eligible with a mean age of 10.4±3.4 years. The majority of subjects sustained bicortical distal radius fractures (68%), followed by Salter-Harris II physeal fractures (27%). Overall 616/655 children (94%) were eligible for radiographic analysis, and the rate of radiographic LOR was 43% (262/616). LOR was more likely in patients <11 years old (53% vs. 33%) and in metaphyseal fractures compared to physeal fractures (51% vs. 24%). Patient body mass index (BMI) did not influence rate of LOR. Increased fracture translation at the time of injury had a higher rate of LOR; 64% of fractures with >100% translation had LOR compared to only 25% of non-translated fractures ($p<0.001$, **Table 1**). Similarly, radial fractures with a concomitant ulnar fracture had a significantly higher rate of LOR (47% vs. 27%, $p<0.001$; **Table 1**). On multivariate analysis, bicortical radial fracture type, >50% radial translation on pre-reduction films, and presence of a metaphyseal or diaphyseal ulnar fracture each independently and significantly increased the odds of LOR (**Table 2**).

Ultimately, 47/655 children (7%) were indicated for secondary procedures, including repeat closed reduction or surgical treatment. Children with self-identified white race ($p<0.001$), increased pre-reduction translation ($p=0.002$), and pre-reduction angulation ($p=0.013$) were more likely to undergo a secondary procedure (**Table 1**). On multivariate analysis, only patient race was a significant predictor for a secondary procedure (**Table 2**).

DISCUSSION AND CONCLUSION:

This investigation reports radiographic loss of reduction from a large, prospective multicenter cohort of pediatric distal radius fractures. Overall 44% of pediatric distal radius fractures had radiographic LOR and 7% underwent repeat reduction or secondary surgical treatment. Bicortical fracture type, >50% translation on pre-reduction films, and concomitant metaphyseal or diaphyseal ulna fracture independently increase the odds of LOR for pediatric distal radius fractures. Patient body mass index does not appear to influence LOR. Future investigations will clarify the relationships between LOR and immobilization characteristics, as well as the relationships between patient race, socioeconomic status, and secondary procedures.

TABLE 1: Risk factors for Loss of Reduction in Pediatric Distal Radius Fractures and Need for Secondary Procedure(s)

	No LOR	LOR[†]	p	No Secondary Procedure	Secondary Procedure[‡]	p
# Subjects (%)	354 (58%)	262 (42%)		608 (93%)	47 (7%)	
Patient Characteristics						
Sex			0.155			0.234
Male	254 (59%)	174 (41%)		415 (92%)	36 (8%)	
Female	100 (53%)	88 (47%)		193 (94%)	11 (5%)	
Age at DOI			**<0.001**			0.132
4-5 yo	29 (44%)	37 (56%)		59 (88%)	8 (12%)	
6-10 yo	134 (50%)	132 (50%)		269 (95%)	15 (5%)	
11+ yo	191 (67%)	93 (33%)		280 (92%)	24 (8%)	
BMI Percentile			0.378			0.977
Underweight/Healthy, <85th percentile	208 (59%)	142 (41%)		342 (92%)	29 (8%)	
Overweight, 85-95th percentile	56 (53%)	49 (47%)		101 (93%)	8 (7%)	
Obese, >95th percentile	70 (54%)	60 (46%)		126 (93%)	10 (7%)	
Race			0.158			**<0.001**
White	246 (59%)	173 (41%)		400 (90%)	42 (10%)	
Black	34 (49%)	37 (51%)		118 (99%)	1 (1%)	
Mixed/Other	35 (58%)	24 (42%)		64 (98%)	1 (2%)	
Injury Characteristics						
Injury Mechanism			**<0.001**			0.741
Sport	131 (72%)	51 (28%)		178 (93%)	14 (7%)	
Low Energy Fall (Not Sport)	31 (54%)	27 (47%)		63 (93%)	5 (7%)	
High Energy Fall (Trampoline, etc.)	119 (47%)	134 (53%)		247 (93%)	18 (7%)	
Motor vehicle (ATV, car, etc.)	9 (82%)	2 (18%)		12 (100%)	0 (0%)	
Body powered vehicle (Bike, etc.)	56 (59%)	39 (41%)		88 (90%)	10 (10%)	
Direct blow (Punching, etc.)	7 (47%)	8 (53%)		18 (100%)	0 (0%)	
DR Fracture Type			**<0.001**			0.158
Metaphyseal bicortical	205 (49%)	214 (51%)		408 (92%)	36 (8%)	
Metaphyseal greenstick	12 (75%)	4 (25%)		17 (100%)	0 (0%)	
Intra-articular	3 (75%)	1 (25%)		3 (75%)	1 (25%)	
Physeal	134 (70%)	43 (24%)		180 (95%)	10 (5%)	
Physeal Fracture type			0.691			0.051
Physeal, Salter I	7 (88%)	1 (12%)		8 (100%)	0 (0%)	
Physeal, Salter II	171 (79%)	46 (79%)		166 (95%)	8 (5%)	
Physeal, Salter IV	4 (67%)	2 (33%)		4 (67%)	2 (33%)	
Max Translation before CR			**<0.001**			**0.002**
0%	64 (75%)	21 (25%)		92 (97%)	3 (3%)	
1-25%	109 (61%)	70 (39%)		185 (97%)	5 (3%)	
26-50%	44 (75%)	15 (25%)		57 (91%)	6 (9%)	
51-100%	70 (58%)	51 (42%)		113 (91%)	11 (9%)	
>100%	58 (36%)	102 (64%)		142 (87%)	21 (13%)	
Angulation before CR, median (IQR)	22 (15-29)	21 (16-30)	0.514	21 (15-28)	24.5 (18-36)	**0.014**
Presence of ulna fracture			**<0.001**			0.271
Yes	260 (53%)	228 (47%)		476 (92%)	40 (8%)	
No	94 (73%)	34 (27%)		132 (95%)	7 (5%)	
Ulna fracture location						
Ulnar styloid tip	59 (71%)	24 (29%)	**0.007**	64 (93%)	4 (7%)	0.810
Ulnar styloid base	31 (82%)	7 (18%)	**0.002**	38 (97%)	1 (3%)	0.350
Physeal ulna fracture	19 (61%)	12 (39%)	0.659	31 (94%)	2 (6%)	1.000
Metaphyseal ulna fracture	118 (44%)	152 (56%)	**<0.001**	262 (91%)	25 (9%)	0.179
Diaphyseal ulna fracture	31 (46%)	40 (54%)	**0.033**	69 (91%)	7 (9%)	0.465

[†] LOR defined as a change in angulation of ≥10 degrees or change in translation of ≥50% occurring post-closed reduction

[‡] Secondary Procedure defined as any form of repeat closed reduction in the ED/OR or any open reduction or pinning in the OR. Cast wedge is NOT considered a secondary procedure.

TABLE 2: Results of Multivariate Logistic Regression for (A) Radiographic LOR and (B) Secondary Procedure

	Odds Ratio (OR)	95% Confidence Interval	p
A. Significant Predictors for LOR			
Distal Radius Fracture Type – Bicortical [†]	2.06	[1.28, 3.33]	**0.003**
Pre-Reduction Translation >51% [††]	3.11	[1.72, 5.61]	**<0.001**
Concomitant Ulna Fracture – Metaphysis[†††]	2.41	[1.28, 4.55]	**0.007**
Concomitant Ulna Fracture – Diaphysis[†††]	2.21	[1.04, 4.70]	**0.040**
B. Significant Predictors for Secondary Procedure			
Race – Black/African American[*]	0.09	[0.01, 0.65]	**0.017**

[†] Compared to physeal fractures
[††] Compared to non-translated fractures
[†††] Compared to no metaphyseal/diaphyseal ulna fracture
[*] Compared to white race