

Risk Factors of Stiffness after Surgical Fixation of Pediatric Humeral Lateral Condyle Fractures

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INTRODUCTION: Pediatric humeral lateral condyle fractures are the second most common elbow fracture. Surgically treating these fractures pose challenges due to their physeal and intra-articular involvement. Postoperative elbow stiffness is a common concern due to restricted limb functionality that burdens patients with additional follow up and associated costs. This study aims to identify risk factors for postoperative stiffness for pediatric lateral condyle fractures.

METHODS: A large, multicenter retrospective review of medical records from six level I trauma centers was conducted. Data from children aged 1 to 12 years with lateral humeral condyle fractures treated between 2005 and 2019 were collected. Patient demographics, fracture characteristics, open and closed reduction approaches, and complications were analyzed. Postoperative stiffness was defined as a lack of full flexion or extension at final follow up or a need for receiving physical or occupational therapy services. Multivariable logistic regression was performed to identify risk factors for postoperative stiffness. Statistical significance was set to 0.05.

RESULTS: A total of 665 fractures were analyzed, among which 526 (79%) had normal elbow range of motion at final follow up and 139 (21%) experienced stiffness. The stiffness group had older patients, a higher incidence of initial elbow dislocations, a greater amount of displacement, more severe fracture patterns from Song and Jakob classifications, and a higher rate of open reduction and K-wire fixation procedures. Regression analysis identified open reduction (adjusted OR 1.87, 95% CI [1.09-3.19]; p = 0.022), increased age (adjusted OR 1.09, 95% CI [1.04-1.15]; p = 0.001), and concurrent elbow dislocations (adjusted OR 1.64, 95% CI [1.003-2.68]; p=0.048) as significant risk factors for postoperative stiffness. Among the 139 patients that experienced stiffness, the majority (96%) required physical or occupational therapy, with only 4% requiring additional surgical interventions such as capsulotomies and contracture releases.

DISCUSSION AND CONCLUSION: The study highlights the risk factors for postoperative stiffness in pediatric humeral lateral condyle fractures, most importantly increased age, associated elbow dislocation, and need for open reduction.

Early initiation of range of motion exercises may also be beneficial for at-risk patients.

TABLE 1: Baseline Demographics

	N	Mean	SD	P
Year of Fracture (SD)	665	17.5	2.1	<0.001
Male (n, %)	575 (86.5)			<0.001
Female (n, %)	90 (13.5)			
Fracture location (SD)	253 (38.2)			<0.001
Distal humerus (n, %)	190 (28.6)			
Proximal humerus (n, %)	64 (9.6)			
Proximal radius/ulna (n, %)	17 (2.6)			
Distal radius/ulna (n, %)	11 (1.7)			
Elbow instability (n, %)	19 (2.9)			
Open reduction (n, %)	124 (18.7)			<0.001
Closed reduction (n, %)	541 (81.3)			
Plating (n, %)	112 (16.8)			<0.001
K-wire (n, %)	429 (64.2)			
Intra-articular fixation (n, %)	544 (81.8)			<0.001
Extra-articular fixation (n, %)	121 (18.2)			
Displacement (mm) (SD)	3.2	1.8	<0.001	
Displacement (%) (SD)	15.2	7.5	<0.001	
Days of displacement to final follow-up (SD)	11.2	4.1	<0.001	
Final displacement (mm) (SD)	2.8	1.6	<0.001	
Final displacement (%) (SD)	13.1	6.8	<0.001	
Final displacement to post-operative to rest (mm) (SD)	1.8	1.0	<0.001	
Final displacement to post-operative to rest (%) (SD)	8.5	4.5	<0.001	

TABLE 2: Postoperative Stiffness

	No. Stiffness n, (N, %)	Stiffness n, (N, %)	OR	95% CI	P
Age at fracture (years)	15 (2)	190	1.09	[1.04-1.15]	<0.001
Male	13 (9)	562	1.87	[1.09-3.19]	0.022
Female	6 (4)	83			
Fracture location					
Distal humerus	10 (7)	180			
Proximal humerus	3 (2)	61			
Proximal radius/ulna	1 (0.6)	16			
Distal radius/ulna	0 (0)	17			
Elbow instability	1 (0.6)	18			
Open reduction	3 (2)	121			
Closed reduction	136 (36)	46 (13)			
Plating	8 (2)	27 (8)			
K-wire	3 (1)	46 (13)			
Intra-articular fixation	136 (36)	46 (13)			
Extra-articular fixation	12 (3)	109			

TABLE 3: Final Regression Model

	P	OR	95% CI
Open reduction	0.022	1.87	[1.09-3.19]
Age at fracture	0.001	1.09	[1.04-1.15]
Elbow instability	0.048	1.64	[1.003-2.68]
Displacement	0.113	1.08	[0.92-1.26]
Days to displacement	0.114	1.02	[0.99-1.05]

TABLE 4: Stiffness requiring PFT or Surgery

	PFT	Surgery	P
Age at fracture (years)	15 (11)	24 (17)	<0.001
Male	13 (9)	24 (17)	<0.001
Female	2 (1)	0 (0)	
Fracture location			
Distal humerus	10 (7)	18 (13)	
Proximal humerus	3 (2)	8 (6)	
Proximal radius/ulna	1 (0.6)	16 (11)	
Distal radius/ulna	0 (0)	17 (12)	
Elbow instability	1 (0.6)	18 (13)	
Open reduction	3 (2)	121 (87)	
Closed reduction	136 (36)	46 (33)	
Plating	8 (2)	27 (20)	
K-wire	3 (1)	46 (33)	
Intra-articular fixation	136 (36)	46 (33)	
Extra-articular fixation	12 (3)	109 (78)	

TABLE 5: Stiffness requiring PFT or Surgery (continued)

	Open	Closed	P
Type of Fracture (n, %)			
Distal humerus	10 (7)	18 (13)	
Proximal humerus	3 (2)	8 (6)	
Proximal radius/ulna	1 (0.6)	16 (11)	
Distal radius/ulna	0 (0)	17 (12)	
Elbow instability	1 (0.6)	18 (13)	
Open reduction	3 (2)	121 (87)	
Closed reduction	136 (36)	46 (33)	
Plating	8 (2)	27 (20)	
K-wire	3 (1)	46 (33)	
Intra-articular fixation	136 (36)	46 (33)	
Extra-articular fixation	12 (3)	109 (78)	

OR, odds ratio; CI, confidence interval; PFT, physical/occupational therapy; * indicates significant result (p < 0.05).