Skin Tenting Associated with Completely Displaced Midshaft Clavicle Fractures in Adolescents: Results from the FACTS Multicenter Prospective Cohort Study

Joshua Hei-Nan Pang, Samuel Clifton Willimon, Philip L Wilson[1], Donald S Bae[2], Michael T Busch[3], Eric William Edmonds, Henry Bone Ellis[4], Mininder S Kocher[5], G. Ying Li, Jeffrey J Nepple[6], Nirav Kiritkumar Pandya, Andrew Tennant Pennock, Crystal Ann Perkins, Coleen S Sabatini[7], David D Spence, Benton E Heyworth[8]
[1]Scottish Rite For Children, [2]Children's Hosp Boston, [3]Children's Healthcare of Atlanta, [4]Texas Scottish Rite Sports Medicine, [5]Boston Children's Hospital, Dept of Ortho Surg, [6]Washington University, [7]UCSF Dept. of Orthopaedic Surgery, [8]Boston Children's Hospital

INTRODUCTION: Skin tenting is a commonly applied relative indication for operative treatment of clavicle fractures. However, the influence of this injury feature and optimal treatment for patients with skin tenting has been minimally investigated, particularly in adolescent populations, despite being the most affected epidemiologic subgroup. This study therefore sought to evaluate the outcomes of non-surgically and surgically treated clavicle fractures associated with skin tenting in the adolescent population.

METHODS:

Ten to 18 year-old patients with completely displaced mid-shaft clavicle fractures who received nonsurgical or surgical treatment at one of eight participating institutions between 2013 and 2022 were screened for two categories of skin tenting at initial presentation: 1) ‘skin tenting’ or 2) ‘skin-at-risk for necrosis’ (described as tented, white, hypovascular). Additionally, demographic and fracture characteristics and treatment were recorded, and patients were followed for a minimum of one year. Return to sport (RTS) time, validated patient-reported outcomes (PROs: ASES, Quick DASH, Marx shoulder activity, and EQ-VAS), and complications were analyzed.

RESULTS: Of the 768 prospectively enrolled adolescents with completely displaced midshaft clavicle fractures, the 92 (12%) patients who were reported to have ‘skin tenting’ or ‘skin-at-risk’ demonstrated greater age, comminution, shortening, and superior displacement, when compared to the 676 patients without tenting (Table 1). Of those with tenting, 32 (35%) were treated nonsurgically (Non-Op), while 60 (65%) underwent open reduction and internal fixation (ORIF) (Table 2). Three Non-Op patients (9%) were converted to ORIF treatment at a mean of 20.0 days (range, 6-41 days) post-injury, due to increased symptoms or clinical concern. While nonsurgically treated patients were, on average, less than one year younger than operative patients (Non-Op 14.5 years; ORIF 15.4 years, p=0.02), there were otherwise no significant differences between treatment cohort characteristics, including sex (Non-Op 81% males; ORIF 90% males, p=0.13), shortening (p=0.10), superior displacement (p=0.06), and comminution (p=0.20). The majority of patients provided PROs at 1 or 2 years post-treatment (64%), with no difference in response rates between treatment cohorts. There were no significant differences in RTS time, PRO scores, activity scores, or complications between the two cohorts (RTS: p=0.70, ASES: p=0.16, Quick DASH: p=0.07, Marx: p=0.26, EQ-VAS: p=0.68, complications: p=0.99).

DISCUSSION AND CONCLUSION: In this prospective multicenter cohort study, the subset of adolescent clavicle fracture patients with skin tenting or skin-at-risk for necrosis showed no differences in complications, PROs, or RTS, whether treated nonsurgically and surgically. The reasons for these findings warrant further exploration, but may be due to early fracture settling, enhanced healing capacity, and bony remodeling potential that is unique to younger patients, and which may allow for tolerance of skin tenting without adverse effects. These data suggest that nonsurgical treatment with early observation may be associated with comparably good results, allowing for rare instances of conversion to surgical treatment when clinically warranted.

Table 1: Comparison of Patients with Skin Tenting/Skin-At-Risk vs. NO Skin Tenting/Skin-At-Risk			
	Skin Tenting/ Skin-At-Risk (*n = 92; 12%*)	**NO Skin Tenting/ Skin-At-Risk (*n = 676; 78%*)**	**p-value**
Sex			0.07
Male	80 (87%)	528 (78%)	
Female	12 (13%)	148 (22%)	
Age (*years; mean (SD)*)	15.1 (+/- 1.7)	14.4 (+/-2.1)	<0.001
Treatment			<0.001
ORIF	60 (65%)	171 (25%)	
Non-Op	32 (35%)	505 (75%)	
Fracture Characteristics	n = 92	n = 669	
Comminuted	50 (54%)	186 (28.1%)	<0.001
End-to-End Shortening (*mm; mean (SD)*)	25.3 (+/- 9.9)	23.1 (+/- 8.9)	0.03
Superior Displacement (*mm; mean (SD)*)	18.0 (+/- 7.0)	14.8 (+/- 5.8)	<0.001

Table 2: Comparison of Treatment Groups Amongst 92 Patients with Skin Tenting/Skin-At-Risk			
	Non-Op (n = 32)	**ORIF (n = 60)**	**p-value**
Sex			0.13
Male	25 (78%)	55 (92%)	
Female	7 (22%)	5 (8%)	
Age (*years; mean (SD)*)	14.5 (+/- 1.9)	15.4 (+/- 1.5)	0.02
Skin Appearance			
Tenting	30 (94%)	58 (97%)	
At-Risk	2 (6%)	2 (3%)	
Fracture Characteristics			
Comminuted	14 (45%)	36 (59%)	0.20
End-to-End Shortening (*mm; mean (SD)*)	23.2 (+/- 8.1)	26.5 (+/- 10.6)	0.10
Superior Displacement (*mm; mean (SD)*)	16.3 (+/- 5.5)	19.0 (+/- 7.5)	0.06
Return to Sport (*weeks; mean (SD)*)	9.0 (+/- 4.9)	9.6 (+/- 6.2)	0.70
Completed PROs*	16 (52%)	43 (70%)	0.47
Time to follow-up (*months; mean (SD)*)	25.9 (+/- 8.3)	26.4 (+/- 11.7)	0.86
ASES (*median (IQR)*)	100 (100 - 100)	100 (96.7 - 100)	0.16
Quick DASH (*median (IQR)*)	0 (0 - 0)	0 (0 - 2.3)	0.07
Marx (*median (IQR)*)	18 (13 - 20)	16 (10 - 20)	0.26
EQ-VAS (*median (IQR)*)	95 (90 – 100)	95 (89 – 99)	0.68
Complications	4 (13%)	6 (10%)	0.99
Patients initially treated non-operatively subsequently converted to ORIF, due to increased symptoms or clinical concern	3 (9%)	--	
Symptomatic Malunion	1 (3%)	--	
Unexpected/Secondary Surgeries	4 (13%)	4 (7%)	
Hardware-related Complaints/Symptoms	--	4 (7%)	
Wound Dehiscence	--	1 (2%)	
Delayed Union	--	1 (2%)	
Nonunion	--	1 (2%)	
Refracture	--	1 (2%)	

* Patient-reported outcomes (PROs) at 1-year and/or 2-year follow up time points