Remodeling of Pediatric Tibial Shaft Fractures: What Should We Expect?

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INTRODUCTION:

Tibial shaft fractures account for up to 14.8% of all pediatric fractures in large population studies. The majority of tibial shaft fractures are closed injuries, most of which are managed nonoperatively with closed reduction and casting. There are guidelines for acceptable amounts of angulation, shortening and translation; however, it is not known how much remodeling occurs over time in pediatric patients The purpose of this study is to quantify the expected angulation at 6 months post-injury and to determine whether the degree of angulation varies by age.

METHODS:

We included patients who presented to a major pediatric health system between January 2009 and August 2023 with closed tibial shaft fractures. Participants were identified based on ICD-9 and ICD-10 diagnosis codes for tibial fractures. Eligible patients were children under 17 years of age with radiographs at baseline and at 6 months of follow-up. Exclusion criteria included operatively managed fractures, open fractures, comminuted fractures, re-fractures, history of malignancy, metabolic diseases, or lack of imaging within the specified timeframe. Relevant data were extracted from the electronic medical record. Radiographs were reviewed to assess angulation, translation, and shortening in the coronal and sagittal planes. These measurements were performed on post-reduction radiographs and at 6-month follow-up. All measurements were performed on our electronic imaging system. Statistical analyses aimed to compare differences in baseline and follow-up measurements between two age groups: (i) children under 8 years old and (ii) children aged 8-16 years. All statistical analyses were conducted using R.

RESULTS:

This study included 38 patients (14 females and 24 males) with an average age of 7.3 years (Range – 1 year to 14 years). At baseline, the average fracture translation was 3.5 mm in the sagittal plane and 2.8 mm in the coronal plane. All patients demonstrated complete correction of fracture translation in both planes at 6 months post-injury ($p < 0.001$). Younger children exhibited significant sagittal plane remodeling (2.68° vs. 1.27°, $p < 0.01$), whereas coronal plane remodeling was not significantly different between age groups. The younger group had a significantly lower residual angulation in the coronal (1.31° vs. 2.38°, $p = 0.04$) and sagittal (1.27° vs. 3.38°, $p = 0.02$) plane at 6 months. On average, the older group had a significantly longer use of short-leg cast (3.6 vs. 1.4 weeks, $p < 0.001$), as well as more frequent participation in physical therapy (81.3% vs. 27.1%, $p < 0.01$).

DISCUSSION AND CONCLUSION:

This study demonstrates that pediatric tibial shaft fractures treated nonoperatively exhibit substantial remodeling capacity, particularly in younger children and in the sagittal plane. Translation and shortening consistently resolved within six months in all patients. Children under 8 years old showed significantly greater remodeling in both sagittal and coronal planes, with sagittal correction reaching statistical significance, consistent with prior literature. In contrast, older children showed limited remodeling, especially in valgus and posterior deformities.

Our results reinforce established guidelines suggesting that angulation up to 10° may remodel in younger children, while more conservative thresholds should be maintained for older children. Despite over half of our cohort presenting with >18% translation—a value previously associated with re-displacement—we observed no such events, possibly due to differences in age, immobilization protocols, or intrinsic remodeling capacity.

Immobilization strategies differed by age, with older children more frequently transitioning to a short-leg cast (SLC) after initial long-leg cast (LLC) immobilization. This likely reflects their greater compliance with weightbearing restrictions and supports more flexible casting strategies in this group. These findings emphasize the importance of tailoring treatment based on age, fracture pattern, and patient reliability.

Limitations include a small sample size, short-term follow-up, single-center data, and retrospective design, all of which limit generalizability and increase susceptibility to bias. Nonetheless, this study offers valuable insight into the natural remodeling course of pediatric tibial fractures.

In conclusion, nonoperative management remains a reliable treatment strategy for pediatric tibial shaft fractures, particularly in younger children, where greater angulation and displacement may be acceptable. However, stricter reduction criteria and close follow-up are advised in older patients due to reduced remodeling potential. Future prospective, multicenter studies with longer follow-up and incorporation of patient-reported outcomes are warranted to refine treatment thresholds and guide individualized care.

	Age (<8) N=22		Age (8 to 16) N=16		
	N	%	N	%	p-value*
Fracture Type					0.35
Oblique	13	59.1	13	81.3	
Spiral	6	27.3	2	12.5	
Transverse	3	13.6	1	6.3	
Fracture Location					0.3
Proximal 3rd	0	0	1	6.3	
Middle 3rd	11	50	5	31.3	
Distal 3rd	11	50	10	62.5	
Sagittal Orientation					<0.01
Apex Anterior	17	77.3	6	37.5	
Apex posterior	2	9.1	9	56.2	
Neutral	3	13.6	1	6.2	
Coronal Orientation					0.54
Varus	10	45.5	9	56.2	
Valgus	6	27.3	5	31.2	
Neutral	6	27.3	2	12.5	
Injury Etiology					0.22
Sports/Recreational	18	81.8	9	56.2	
MVA	2	9.1	1	6.2	
Domestic Accident	2	9.1	3	18.8	
Other	0	0	3	18.7	
Associated Fracture					0.27
Fibula	6	27.3	8	50	
Rehabilitation					<0.01
PT	6	27.3	13	81.3	

*From chi-square tests

		Age <8		Age 8 to 16		
		Mean	Max	Mean	Max	p-value*
Baseline Translation, %						
	Coronal	13.5 (18.1)	68.9	20.9 (13.5)	43.7	0.15
	Sagittal	15.1 (13.7)	43.8	24.1 (17.3)	57.1	0.09
Baseline Angulation, °						
	Coronal	2.27 (2.58)	17	2.56 (2.28)	9	0.3
	Sagittal	2.68 (2.95)	10	4.19 (3.41)	12	0.1
Baseline Shortening, mm						
	Axial	0.87 (2.27)	7.5	0.53 (1.44)	4.4	0.57
Follow-up Translation, %						
	Coronal	0	0	0	0	
	Sagittal	0	0	0	0	
Follow-up Angulation, °						
	Coronal	1.31 (2.87)	10	2.38 (1.96)	8	0.04
	Sagittal	1.27 (2.19)	7	3.38 (2.87)	8	0.02
Follow-up Shortening, mm						
	Axial	0	0	0	0	

*From independent t-tests, (Standard Deviation)

		Age (<8) N=22		Age (8 to 16) N=16		
		N	%	N	%	p-value*
Sex						0.64
	Female	8	36.4	7	43.8	
	Male	14	63.6	9	56.3	
Race/Ethnicity						0.49
	Non-Hispanic, Black	1	4.5	0	0	
	Non-Hispanic Other	5	22.7	7	43.8	
	Non-Hispanic White	7	31.8	4	25	
	Hispanic/Latino	9	40.9	5	31.3	
Insurance						0.96
	Public	11	50	11	68.8	
	Private	11	50	7	43.8	

*From chi-square tests