Rigid Intramedullary Nails for Adolescent Tibial Shaft Fractures: Safe or Source of Deformity?

Grant Stevens McHorse[1], K John Wagner, Christopher D Souder
[1]Orthopaedic Surgery, Dell Medical School at University of Texas Austin

INTRODUCTION: Tibial shaft fractures represent a common adolescent fracture. Though nonsurgical management via closed reduction and casting remains a common method of treatment, operative stabilization is increasingly common. Most surgeons utilize elastic intramedullary nails (EIN) or open reduction internal fixation (ORIF) with plate and screw constructs when surgical fixation is needed in skeletally immature patients due to concern for iatrogenic growth deformity. Rigid intramedullary nails (RIMN) require reaming across the anterior proximal tibial physis leading to concern for subsequent physeal injury and growth disturbance. EIN often require postoperative weight-bearing restrictions and fail to provide rotational control. This technique may also be unsuitable for some length unstable fractures. Both EIN and ORIF often require a second surgery for hardware removal. RIMN provides rotational stability via interlocking screws while also affording the surgeon the opportunity to treat more proximal or distal fractures. Currently, there is little evidence evaluating the outcomes of RIMN in skeletally immature patients despite the practice having been widely adopted in adults. It is generally accepted there is a theoretical risk of recurvatum due to physeal injury with RIMN in skeletally immature patients. The objective of this study is to determine if RIMN are a safe and effective means of treating tibial shaft fractures in adolescent patients with open physes.

METHODS: A retrospective chart review was performed of tibial shaft fractures treated via RIMN within a single pediatric orthopaedic group between January 7, 2012 to September 20, 2022. Patients with closed physes were excluded. Primary outcome measurements were intraoperative medial proximal tibial angle (MPTA) and posterior proximal tibial angle (PPTA) as well as MPTA and PPTA measured on last available radiographs. Radiographs were also evaluated for the presence of end caps and location of the proximal end of the implant relative to the physis. Intraoperative and postoperative measurements were compared using a paired sample t-test at a significance level of 0.05. Change in MPTA and PTPA based on nail location was assessed using a two sample t-test at a significance level of 0.05.

RESULTS:

Twenty-three patients (20 males, 3 females) were included in the study. Mean age was 14.4 years at time of surgery and mean follow up was 14.7 months. There was no statistically significant difference between mean MPTA measured pre- and postoperatively (87.348 ± 1.335 vs. 86.826 ± 1.403, p = .0967) nor between mean PPTA pre- and postoperatively (81.087 ± 1.411 vs. 82.000 ± 4.973, p = .352).

There was a statistically significant difference in absolute change in PPTA between those with implant left above the physis compared to those with nail below the physis (0.944 ± 0.873 vs. 5.600 ± 8.649, p = .026), though after exclusion of one patient with significant recurvatum the difference was no longer statistically significant.

One patient did have significant recurvatum in the sagittal plane after being treated with RIMN with the nail left distal to the physis. The patient's initial MPTA and PPTA were 87 and 83 degrees postoperatively compared with 85 and 104 degrees at follow up of 31 months after surgery.

DISCUSSION AND CONCLUSION:

The use of RIMN in skeletally immature adolescents did not lead to a statistically significant change in MPTA or PPTA indicative of growth disturbance. It is important to note that one patient developed significant recurvatum in the sagittal plane after RIMN with the implant left below the physis. There was not a statistically significant difference in absolute change in MPTA or PPTA based on final implant position after exclusion of this single outlier.

Though our series confirms RIMN are generally safe and effective in treating tibial shaft fractures in skeletally immature adolescents, we demonstrate there is a non-zero risk of sagittal recurvatum by including, to our knowledge, the first published incidence of recurvatum following the use of RIMN in an adolescent tibial shaft fracture. Further studies are needed to elucidate which patients may be at risk for growth arrest and whether location of implant relative to the physis portends any increased risk.

Figure 2. AP and lateral radiographs demonstrating sagittal recurvatum deformity after treatment with rigid intramedullary nail.

Figure 1. Example AP and lateral radiographs of skeletally immature adolescent patient after treatment with rigid intramedullary nail.

Table 1. Demographic Characteristics of Study Population

Demographic Variable	Median Value (Range) (n=23)
Male/Female (%)	87%/13%
Age at Surgery (years)	14.3 (13.2-16.4)
Follow up (months)	7.0 (2-45)
Intraoperative Radiographic findings Proximal Tibial Physis Open/Closed Tibial Apophysis Ossified/Closed	100%/0% 87%/13%
Follow Up Radiographic findings Proximal Tibial Physis Open/Closed Tibial Apophysis Ossified/Closed	48%/52% 22%/78%

Table 2. Statistical Analysis of Medial Proximal Tibial Angle and Posterior Proximal Tibial Angle

	Intraoperative	Follow Up	p-value
All patients (n = 23)			
Medial Proximal Tibial Angle (MPTA, deg)	87.348	86.826	.0967
Posterior Proximal Tibial Angle (PPTA, deg)	81.087	82.000	.352
Implant Above Physis (n = 18)			
Medial Proximal Tibial Angle (MPTA, deg)	87.389	87.056	0.317
Posterior Proximal Tibial Angle (PPTA, deg)	80.890	81.056	0.592
Implant Below Physis (n = 5)			
Medial Proximal Tibial Angle (MPTA, deg)	87.200	86.000	0.178
Posterior Proximal Tibial Angle (PPTA, deg)	81.800	85.400	0.441

Table 3. Comparison of absolute change in MPTA and PPTA for implant above vs below physis

	Implant Above Physis (n=18)	Implant Below Physis (n=5)	p-value
Absolute Change in MPTA (deg)	1.000	1.600	0.251
Absolute Change in PPTA (deg)	0.944	5.600	**0.026**

With recurvatum patient excluded, the difference is not statistically significant