

Patient and Surgical Risk Factors Correlated with Postoperative Stiffness following Arthroscopic Tibial Spine Fracture Fixation

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INTRODUCTION: Tibial spine fractures (TSF) are rare injuries, affecting approximately 3 per 100,000 patients annually. Stiffness is the most common postoperative complication following surgical fixation of TSF. With the recent shift toward arthroscopic TSF fixation, patient specific risk factors and surgical parameters correlated with postoperative stiffness remain unclear. The purpose of this analysis is to identify the rates of stiffness and associated risk factors in pediatric TSF patients using a prospective registry and standardized complication classification system.

METHODS: A prospective, multicenter registry designed to track complications of pediatric knee arthroscopy (SCORE) collected de-identified peri-operative data between 2018-2025 from 43 surgeons at 27 different participating institutions. Participating sites logged consecutive TSF cases into a HIPAA-compliant electronic platform. Complications were graded according to the Modified Clavien-Dindo-Sink Complication Classification. For this study's purposes, flexion loss, extension loss, and combined flexion and extension loss were grouped as postoperative stiffness. Grade II stiffness was defined as a case with motion loss resulting in significant deviation from standard postoperative management. Grade III stiffness was defined as motion loss that required unplanned secondary surgical management, or unplanned hospital readmission. Patient demographics, injury data (Meyers and McKeever classification, meniscal injury), surgical data, and post-operative data were analyzed for correlation with postoperative stiffness. Descriptive statistics were calculated, and data were analyzed using Chi-Squared and Fisher's Exact Test for categorical variables, as well as the Mann-Whitney U Test for continuous variables. Multivariate analysis was performed after controlling for confounding variables including patient demographics, rehabilitation data, injury, and surgical characteristics.

RESULTS:

464 (348 isolated TSF, 116 TSF with meniscus repair) patients were included for analysis. The average age was 12.02 ± 2.77 years (range: 5-18), average BMI was 21.13 ± 5.94 , average injury to surgery interval was 31.4 ± 97.65 days, and there were 343 (73.9%) males. A total of 64 patients (13.8%) developed postoperative stiffness, of which 26 (40.6%) were treated operatively.

Univariate analysis revealed that patients <13 years of age had higher rates of postoperative stiffness (19.0% vs 0.9%; $p = 0.001$). There was no difference in postoperative stiffness rates amongst different tibial spine fractures by Myers and McKeever Classification ($p > 0.05$), however, increased rates of stiffness were seen with the absence of a concomitant meniscal tear (16.0% vs 10.0%; $p = 0.048$) and with fracture extending to the weight bearing surface of the tibia (19.0% vs 12.0%; $p = 0.026$). Higher rates of stiffness were also seen with screw fixation when compared to suture fixation and hybrid (screw and suture) fixation (31.0% vs 13.0% vs 0.0%; $p = 0.004$). When controlling for patient, surgical, and rehabilitation variables, there was a significantly higher risk of developing postoperative knee stiffness in patients <13 years (OR 3.25; 95% CI: 1.65-6.42; $P = 0.001$) and patients with fractures extending to the weight bearing surface of the tibia (OR 2.03; 95% CI: 1.09-3.78, $p = 0.025$). Additionally, those who underwent TSF fixation with the use of a screw (includes hybrid fixation) were at increased risk for development of postoperative knee stiffness when compared with suture alone (OR 2.92; 95% CI: 1.067-8.35; $p = 0.037$). There were no significant differences in rates of stiffness regarding range of motion restriction ($p = 0.090$) or postoperative weight bearing restriction ($p = 0.697$). Table 2 illustrates logistic regressions of associated risk factors in developing postoperative knee stiffness.

DISCUSSION AND CONCLUSION: In this large, multicenter cohort, postoperative stiffness occurred in 13.8% of patients. Higher rates of postoperative stiffness were seen in patients age <13 years, extension of fracture into the weight bearing surface of the tibia, absence of meniscal tear and patients who underwent screw fixation.

Table 1: Demographics, Injury, and Treatment of Postoperative Tibial Spine Fractures

Characteristics	n(%)
Age (SD)	72.02 ± 2.57
Height (range: 160-190)	17.45 ± 0.63
Body Mass Index (SD)	27.13 ± 5.54
Time of surgery (minutes) (SD)	87.88 ± 38.74
Procedure Performed	
Tibial Spine Fixation	348 (76.0)
Tibial Spine Fixation with Meniscus Repair	116 (25.0)
Postoperative Meniscus Tibial Spine Classification	
I	3 (0.6)
II	135 (29.2)
III	259 (56.6)
IV	71 (15.3)
Tibial Spine Fracture	
Isolated Condylar	421 (91.7)
Simple Extension	10 (2.1)
Hybrid - Subarticular Condylar with Bone	8 (1.7)
Continuous Passive Motion	
Received	44 (9.5)
Did Not Receive	420 (90.5)
Cold Therapy	
Received	344 (73.7)
Did Not Receive	124 (26.3)
Categorized Range of Motion Restriction	
None	49 (10.6)
Based in Extension/Ceased	146 (31.5)
Any ROM (30-90°, 0-40°, 0-60°)	269 (58.0)
Duration Range of Motion Restriction (SD)	
Categorized Weight Bearing Restriction	4.30 ± 1.44
Non-Weight Bearing	55 (11.8)
Any Weight Bearing	408 (88.1)
Duration Weight Bearing Restriction (SD)	
4.35 ± 1.73	
Physical Therapy	
Home Exercise Program	45 (9.7)
Outpatient	429 (92.3)
None	1 (0.2)

Table 2: Logistic Regression Analyses of Risk Factors for Developing Postoperative Knee Stiffness Following TSP

	N	OR (95% CI)	P-value
Age			
< 13 years	225	3.25 (1.65-6.47)	0.001
≥ 13 years	239	Reference	
Gender			
Male	343	Reference	
Female	121	0.69 (0.35-1.35)	0.277
Fracture Condylar Fracture			
Simple	10	2.08 (1.07-4.05)	0.037
Subarticular	421	Reference	
Major and Moderate Tibial Spine Classification			
III	134	Reference	
III/IV	338	1.04 (0.53-2.02)	0.916
Presence of Meniscal Tear			
No	207	Reference	
Yes	167	0.74 (0.37-1.46)	0.364
Fracture Extending to Weight Bearing Surface of Tibia			
No	312	Reference	
Yes	145	2.03 (1.09-3.76)	0.025
Concomitant Meniscus Entrapment			
No	362	Reference	
Yes	202	0.98 (0.52-1.77)	0.965
Fixed Rotation			
Non-anatomic	124	Reference	
Anatomic	332	0.90 (0.46-1.76)	0.762
Planned (right) Retrosult			
No	438	Reference	
Yes	22	1.21 (0.30-4.96)	0.789
Flexion			
All Equipment	87	Reference	
Transposed	375	2.32 (0.95-5.98)	0.064
Range of Motion Restriction			
None	49	Reference	

Control/Braced Locked in Extension	146	2.78 (0.65-6.00)	0.090
0-90°	269	1.26 (0.39-4.00)	0.687
Post-operative Weight Bearing Restriction			
Non-Weight Bearing	11	Reference	
Any Weight Bearing	403	1.38 (0.56-3.47)	0.489

Note: Adjusted for patient age, sex, BMI, comorbidity (hypertension, diabetes, and history of osteoarthritis)