# Type IV Tibial Spine Fractures Revisited: Arthroscopic Treatment and Outcomes for an Uncommon Injury

Alexander Adams, BS[1]
Taylor Jackson, BA[1]
Itai Gans, MD[2]
Julien Aoyama, BA[1]
Theodore Ganley, MD[1]

[1]Division of Orthopaedic Surgery
Children's Hospital of Philadelphia, PA

[2]Department of Orthopaedic Surgery
Johns Hopkins Medicine, Baltimore, MD

## Introduction

Tibial spine fractures are most commonly seen in children aged 8 to 14 years and occasionally seen in adults.[1-4] While only occurring in 3 per 100,000 children annually, they are associated with 2-5% of pediatric knee injuries with effusions, and complications including ACL deficiency, arthrofibrosis, and concomitant soft tissue injury.[5-7] Given the ACL's insertion on the tibial spine, injury mechanisms are similar to ACL rupture, involving forced knee flexion with tibial external rotation or hyperextension and lateral movement.[2,8] Although historically caused by bicycle accidents, the rise in competitive youth sports has brought increased public attention to this injury.

Tibial spine fractures were first described by Poncet in 1875,[9] and then fully classified in 1959 by Meyers and McKeever.[8] They described a three-tier classification based on fracture pattern and displacement seen radiographically. Type I fractures are nondisplaced, Type II are displaced anteriorly with an intact posterior hinge, Type III fractures are completely displaced and sub-divided into IIIA (involving only the ACL insertion) or IIIB (involving the entire intercondylar notch).[10] Zaricznyj first described the Type IV fracture as defined by comminuted fragments.[11] Literature focusing specifically on Type IV tibial spine fractures is greatly lacking, despite its status as rare and the most technically difficult to surgically fix with poorer long-term outcomes. Thus, the aim of this retrospective study is to report on the treatment and outcomes of patients treated for Type IV tibial spine fractures at our center.

## Methods

After IRB approval, we retrospectively reviewed all patients between 0 and 18 years old who presented with Type IV tibial spine fracture between 2011-2017 at our single level 1 pediatric trauma center, with classification confirmed by a musculoskeletal radiologist. Demographics, injury and surgical characteristics, and follow-up outcomes were recorded for descriptive analysis.

## Results

Eighteen patients were available for our study. Patient demographics and preoperative injury characteristics are detailed in Table 1. Activities during injury included basketball (3), football (3), skiing (2), trauma (2), trampoline (1), lacrosse (1), bicycle (1), soccer (1), and other activities (4). Soft tissue entrapment and loose bodies were present in 6 of the 18 patients. All patients underwent arthroscopic reduction internal fixation (ARIF). Operative details and follow-up outcomes are detailed in Table 2. Bone bridge technique was utilized in 5/18 patients. There were no malunions or nonunions. Five patients developed arthrofibrosis.

## Discussion

### *Surgical Technique*

Fractures were first visualized via traditional anteromedial and anterolateral arthroscopy portals. Then, lateral and medial mid-patellar portals were placed to allow soft tissue debridement and/or concomitant injury repair. The techniques for Type IV fractures that were performed included the following: sutures placed through drill holes in the proximal tibia that were tied over the anterior proximal tibia, screw and washer fixation, and arthroscopic anchor fixation. Because of the complexity of comminuted Type IV fractures, there were times when a combination of sutures, screws, and anchors were used. For Type IV fractures we then recommend a similar technique to arthroscopic shoulder labral repair using a shoulder anchor.[12] Via the mid-patellar portals, two limbs of high-strength suture were passed through the ACL base and then through the anchors, which are secured in an anterior-to-posterior angle. Intraoperative photographs depicting key steps are included in Figure 1.

### *Outcomes*

Comminuted Type IV fractures are technically difficult to repair and subject to poor outcomes, where May et al found an association between Type IV fractures and decreased Tegner score at 7 years postoperatively.[13] Despite this, most studies combine Type III and Type IV fractures together and have not examined the treatment and outcomes of Type IV fractures specifically.[14,15] In this regard, our goal was to study only the Type IV tibial spine fractures treated at our center between 2011-2017.

Our patients' demographics demonstrate

**Table 1: Patient Demographics and Preoperative Injury Characteristics**

| | |
|---|---|
| **A) Patient Demographics** | |
| Age (Mean ± Standard Deviation) | 13.3 ± 2.6 years |
| Sex (Male:Female Ratio) | 2.6:1.0 |
| BMI (Mean ± Standard Deviation) | 21.9 ± 4.9 |
| Laterality (Right:Left) | 1.3:1.0 |
| **B) Preoperative Characteristics** | |
| Mechanism of Injury | |
| Twisting Non-Contact | 8 / 18 (44%) |
| Contact | 4 / 18 (22%) |
| Hyperextension | 5 / 18 (28%) |
| Not Recorded | 1 / 18 (6%) |
| Preoperative Range of Motion (Mean ± St. Dev.) | |
| Flexion (Degrees) | 104.5 ± 37.6 |
| Extension (Degrees) | 11.4 ± 13.2 |
| Total (Degrees) | 85.5 ± 47.2 |
| Preoperative Physical Exam Findings | |
| Anterior Drawer, Lachman, & Pivot Shift | 1 / 18 (6%) |
| Lachman | 3 / 18 (17%) |
| Pivot Shift | 1 / 18 (6%) |
| No Laxity | 14 / 18(78%) |
| Concomitant Injuries | |
| Meniscal | 5 / 18 (28%) |
| Chondral | 6 / 18 (33%) |
| Ligamentous | 1 / 18 (6%) |
| Ligamentous and Meniscal | 1 / 18 (6%) |
| Chondral and Meniscal | 2 / 18 (11%) |
| Intraarticular Fracture and Chondral | 1 / 18 (6%) |
| None | 2 / 18 (11%) |
| Days Until Treatment (Mean ± St. Dev.) | 9.1 ± 8.1 |

more males of slightly older age than commonly seen with most tibial spine fractures. Activities and injury mechanisms are consistent with literature, with sports quickly becoming the most common cause versus bicycle falls previously.[1] Concomitant meniscus and/or cartilage injuries were most common in our cohort (13/18), consistent with other literature.[16]

Time to treatment represents an area for future focus given its significant length and variability in our study. Watt et al found that patients with prolonged surgical delay and operative duration had increased risk of arthrofibrosis.[17] Others theorize that patients presenting with severe joint stiffness (excluding mechanical obstruction) should improve preoperative range of motion before surgery for better outcomes, similar to prehabilitation goals with ACL rupture.[18] Type IV fractures are almost universally treated operatively and with sutures versus screws, generally consistent with our results although many of our patients underwent combined techniques and may represent more complicated cases referred to our specialists.[14, 19]

Patients' restricted preoperative range of motion (ROM) significantly improved by final follow-up ($p=0.0107$). Total ROM at follow-up was still less than normal; however, this is consistent with literature that has shown 27.8% of Type III and IV have loss of ROM.[15] One method of prevention is ROM rehabilitation within 4 weeks of treatment, which leads to lower rates of arthrofibrosis (0% vs. 36%; $p=0.04$) and earlier return to full activity (103 days vs. 217.5 days; $P=0.02$).[20] In a 2017 survey of Pediatric Orthopaedic Society of North America members, surgeons who treat more than 3 tibial eminence fractures per year were more likely to immobilize fractures for under 2 weeks ($p=0.018$).[21] This is reflected in our results.

Most patients undergo formal physical therapy for multiple months, advancing their activity on a case-by-case basis.

**Table 2: Operative, Postoperative, and Follow-up Results**

| | |
|---|---|
| **A) Operative Details** | |
| Mean ± St. Dev. Operative Time (Min) | 174.7 ± 81.8 |
| Fixation Techniques | |
| Suture(s), Screw(s), & Suture Anchor Fixation | 8 / 18 (44%) |
| Screw(s) & Suture Anchor Fixation | 2 / 18 (11%) |
| Suture(s) & Suture Anchor Fixation | 4 / 18 (22%) |
| Suture(s) & Screw(s) | 1 / 18 (6%) |
| Suture(s) | 1 / 18 (6%) |
| Screw(s) | 1 / 18 (6%) |
| No Internal Fixation | 1 / 18 (6%) |
| **B) Postoperative Details** | |
| Immobilization Technique | |
| Cast | 4 / 18 (22%) |
| Brace | 1 / 18 (6%) |
| Knee Immobilizer | 3 / 18 (17%) |
| No Immobilization | 10 / 18 (56%) |
| Postoperative Protocol | |
| Physical Therapy, Home Exercise, & CPM | 8 / 18 (44%) |
| Physical Therapy & CPM | 3 / 18 (17%) |
| Physical Therapy & Home Exercise | 5 / 18 (28%) |
| Physical Therapy Only | 1 / 18 (6%) |
| Home Exercise & CPM | 1 / 18 (6%) |
| Mean Time Until Knee Mobilization (Days) | 7.6 ± 11.5 |
| Mean Time Until Return to Full Activity (Months) | 9.5 ± 4.5 |
| Follow-up Outcomes | |
| Mean Follow-up with Surgeon (Months) | 14.8± 12.2 |
| Mean Length of Physical Therapy (Months) | 20.6 ± 14.8 |
| Mean Range of Motion at Final Follow-up (Degrees) | |
| Flexion | 127.2 ± 10.3 |
| Extension | −0.4 ± 4.6 |
| Total | 127.7 ± 13.6 |
| Reoperation Incidence | 8 / 18 (44%) |
| Removal of Hardware | 3 / 8 (38%) |
| New Injury | 5 / 8 (63%) |
| Cartilage | 1 / 5 (20%) |
| Meniscus | 2 / 5 (40%) |
| ACL | 2 / 5 (40%) |
| Arthrofibrosis Incidence | 4 / 18 (22%) |

Reoperation rates for hardware removal were low in our cohort, as rates have been reported as high as 65% screw-based fixation and 4% for suture-based fixation.[14] Arthrofibrosis rates for combined groups of Type III and IV have been described as 14.2%,[15] but studies examining this rate in Type IV fractures alone are very limited or non-existent, thus future multi-center retrospective and prospective trials are needed to confirm this rate.

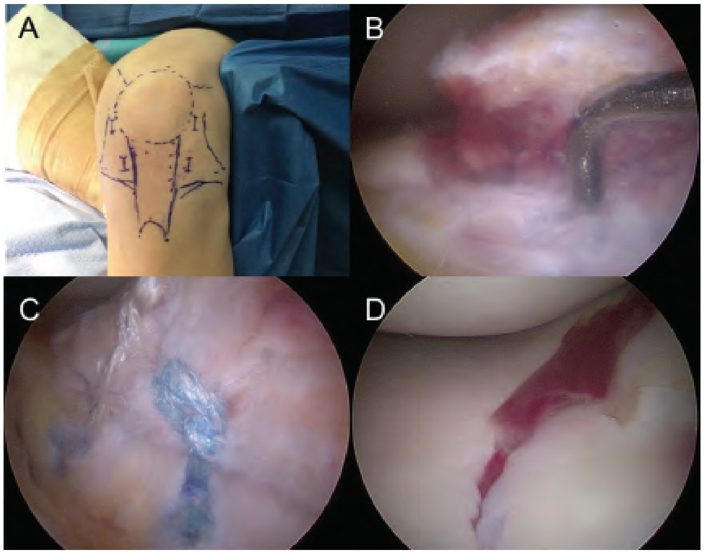


**Figure 1.** Intraoperative photographs of ARIF of tibial spine fracture. **(A)** Preoperative anatomic marking and port placement; **(B)** Displaced tibial spine fracture fragment; **(C)** Fixation of fracture fragments using suture and suture anchors; **(D)** Reduced tibial spine fracture secured with sutures and suture anchors showing anatomic alignment.

## Conclusions

This paper demonstrates the inherent high complication risks and technical difficulty of surgery for Type IV tibial spine fractures, the importance of expeditious treatment, and the need for effective communication and rehabilitation with patients and families.

## References

**1. Aderinto J, Walmsley P, Keating JF.** Fractures of the tibial spine: epidemiology and outcome. *The Knee.* 2008;15(3):164-7.

**2. Chandler JT, Miller TK. T**ibial eminence fracture with meniscal entrapment. *Arthroscopy : the journal of arthroscopic & related surgery.* 1995;11(4):499-502.

**3. Lubowitz JH, Grauer JD.** Arthroscopic treatment of anterior cruciate ligament avulsion. *Clin Orthop Relat Res.* 1993(294):242-6.

**4. Toye LR, Cummings DP, Armendariz G.** Adult tibial intercondylar eminence fracture: evaluation with MR imaging. *Skeletal radiology.* 2002;31(1):46-8.

**5. Pellacci F, Mignani G, Valdiserri L.** Fractures of the intercondylar eminence of the tibia in children. *Ital J Orthop Traumatol.* 1986;12(4):441-6.

**6. Luhmann SJ.** Acute traumatic knee effusions in children and adolescents. *Journal of Pediatric Orthopaedics.* 2003;23(2):199-202.

**7. Eiskjaer S, Larsen S, Schmidt M.** The significance of hemarthrosis of the knee in children. *Archives of orthopaedic and traumatic surgery.* 1988;107(2):96-8.

**8. Meyers MH, Mc KF.** Fracture of the intercondylar eminence of the tibia. *J Bone Joint Surg Am.* 1959;41-A(2):209-20; discussion 20-2.

**9. Poncet A.** Arrachement de l'epine du tibia a l'insertion du ligament croise anterieur. *Bull Mem Soc Chir Paris.* 1875;1:883-4.

**10. Lubowitz JH, Elson WS, Guttmann D.** Part II: arthroscopic treatment of tibial plateau fractures: intercondylar eminence avulsion fractures. *Arthroscopy : the journal of arthroscopic & related surgery.* 2005;21(1):86-92.

**11. Zaricznyj B.** Avulsion fracture of the tibial eminence: treatment by open reduction and pinning. *J Bone Joint Surg Am.* 1977;59(8):1111-4.

**12**. **Gans I, Babatunde OM, Ganley TJ.** Hybrid fixation of tibial eminence fractures in skeletally immature patients. *Arthrosc Tech.* 2013;2(3):e237-42.

13. May JH, Levy BA, Guse D, ***et al.*** ACL tibial spine avulsion: mid-term outcomes and rehabilitation. Orthopedics. 2011;34(2):89.

14. Bogunovic L, Tarabichi M, Harris D, ***et al.*** Treatment of tibial eminence fractures: a systematic review. The journal of knee surgery. 2015;28(3):255-62.

**15. Gans I, Baldwin KD, Ganley TJ.** Treatment and management outcomes of tibial eminence fractures in pediatric patients a systematic review. *The American journal of sports medicine.* 2013:0363546513508538.

16. Kocher MS, Micheli LJ, Gerbino P, ***et al.*** Tibial eminence fractures in children: prevalence of meniscal entrapment. The American journal of sports medicine. 2003;31(3):404-7.

**17. Watts CD, Larson AN, Milbrandt TA.** Open Versus Arthroscopic Reduction for Tibial Eminence Fracture Fixation in Children. *Journal of pediatric orthopedics.* 2016;36(5):437-9.

18. Grindem H, Granan LP, Risberg MA, ***et al.*** How does a combined preoperative and postoperative rehabilitation programme influence the outcome of ACL reconstruction 2 years after surgery? A comparison between patients in the Delaware-Oslo ACL Cohort and the Norwegian National Knee Ligament Registry. Br J Sports Med. 2015;49(6):385-9.

**19. Kocher MS, Micheli LJ, Gerbino P, et al**. Tibial eminence fractures in children: prevalence of meniscal entrapment. *Am J Sports Med.* 2003;31(3):404-7.

20. Patel NM, Park MJ, Sampson NR, ***et al.*** Tibial eminence fractures in children: earlier posttreatment mobilization results in improved outcomes. Journal of Pediatric Orthopaedics. 2012;32(2):139-44.

**21. Jackson TJ, Storey EP, Ganley TJ.** The Surgical Management of Tibial Spine Fractures in Children: A Survey of the Pediatric Orthopaedic Society of North America (POSNA). *Journal of pediatric orthopedics.* 2017.