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Tibial Tubercle Osteotomy in the Management of Patellofemoral Instability—A Review of Radiographic Indications at Two Children's Hospitals

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Introduction

Patellofemoral instability (PFI) is a common condition affecting adolescents with an estimated annual incidence up to 77.4 per 100,00 that is highest among females.[1,2] The Tibial Tubercle Osteotomy (TTO) is a corrective surgical technique utilized in management of PFI for medialization and/or distalization of the knee's extensor mechanism using a variety of described techniques.[3] However, due to the potential risk of physeal injury resulting in growth disturbance, its use is largely limited to those at or approaching skeletal maturity.[4] As such, few large adolescent patient series have been reported in the published literature. Traditionally, a Tibial Tubercle-Trochlear Groove (TT-TG) distance greater than 20mm has been utilized as a threshold for indicating the use of TTO in the adult population, but differential anatomic and environmental risk factors for recurrence among adolescents may drive alternative decision-making in younger patients.[5,6] The purpose of this study was to retrospectively review a large cohort of adolescent PFI patients treated with TTO at 2 large pediatric orthopedic surgery centers and examine actual use patient characteristics for this procedure.

Methods

Following institutional review board approval, a retrospective chart and imaging review of adolescent patients with PFI undergoing TTO from 2007-2021 was conducted at 2 large pediatric orthopedic centers. Inclusion criteria identified all adolescent and young adult patients who presented for surgical treatment of PFI and had operative notes available for review. Patients were excluded if they had history of congenital patellar dislocation or had a previous ipsilateral knee surgery, trauma, or other diagnosis that disrupted the natural anatomy of the knee. Demographics such as age, sex, race, and number of preoperative patellar dislocations were recorded. Preoperative knee MRIs were reviewed to evaluate TT-TG distance, Caton-Deschamps index (CDI), as well as Dejour and Oswestry Bristol classifications of trochlear dysplasia. Operative notes were reviewed to determine if TTO was done to achieve anteromedialization of the extensor mechanism in isolation (AM) or if it was combined with distalization (AMD). Descriptive statistics were used to summarize study variables while bivariate analysis were used to compare traditional surgical indications.

Results

A total of 125 patients (74.8% female) with a mean age of 16.25 years were identified. The median number of patellar dislocations prior to surgery was 3. Anteromedialization (AM) was done in 75 patients while anteromedialization plus distalization (AMD) was done in 50 patients. MPFL reconstruction was performed concurrently in 115 patients (92%) with the remaining 10 (8%) having their reconstruction as a secondary, staged procedure. The mean preoperative TT-TG distance and CDI for the entire cohort were 18.66 mm and 1.33, respectively. Patella alta, defined as a CDI > 1.3, was present in 43 patients (34%). Trochlear dysplasia was prevalent (93.1%) in our cohort with 21% having Dejour D morphology and 31% having OBC Severe dysplasia. TT-TG values were similar ($p > 0.05$) across Dejour and Oswestry-Bristol Classifications and among those with and without patella alta (CDI > 1.3). Significant differences in patellar height were appreciated between AM and AMD groups with a mean CDI of 1.29 and 1.31 for AM and AMD groups respectively ($p = 0.023$). Cohort characteristics are further summarized in Table 1.

Discussion

A lateralized extensor mechanism insertion of the tibia and patella alta are two of the leading modifiable risk factors for recurrent PFI.[6-9] This is one of few studies examining

Table 1. TTO Demographics and Radiographic Summary (N = 125)

Demographic or Radiographic Parameter	Value
Mean Age (SD)	16.25 (2.51)
Sex	
Male	32 (25.2%)
Female	93 (74.8%)
Race	
White	94 (74%)
Black	17 (13.4%)
Asian	6 (4.7%)
Hispanic	2 (1.6%)
Other	8 (6.3%)
Number of Dislocations Prior to Surgery (IQR)	3 (2, 5)
Median Length of Follow Up in Months (IQR)	13.92 (7.56, 28.92)
TTO Type	
AM	75 (60%)
AMD	50 (40%)
TT-TG distance in millimeters (SD)	18.66 (4.29)
Caton-Deschamps index (SD)	1.33 (0.20)
Dejour Classification	
Normal	8 (6.9%)
A	27 (23%)
B	35 (27%)
C	24 (23%)
D	22 (21%)
Oswestry-Bristol Classification	
Normal	8 (6.9%)
Mild	31 (26.7%)
Moderate	41 (35.3%)
Severe	36 (31%)
MPFL Reconstruction	
Concurrent	115 (92%)
Staged	10 (8%)

TTO utilization in the management of PFI in a majority adolescent population. Our study found mean TT-TG distances to be less than the 20mm threshold often cited as an indication for TTO, with no identified differences between trochlear dysplasia classification groups or between patients with and without patella alta.

Normative data in adults suggests that TT-TG distances over 20 mm may indicate surgical correction in symptomatic patients.[5] However, like many radiographic measures, values in adult populations are not directly applicable to pediatric patients who may have anatomic differences due to remaining growth or who may exhibit different risk factors than their adult counterparts. Dickens et al. validated TT-TG using MRI in skeletally immature patients and developed a percentile-based growth curve showing that TT-TG gradually increases with age until reaching normal adult values by 15 years of age.[10] While the aforementioned growth curves may not have been utilized for surgical decision making, it is possible that symptomatic treatment via TTO corresponded to the upper percentiles of TT-TG distances in this largely adolescent population. Previous adult-based studies with similar trochlear dysplasia and patella alta rates demonstrated that combined MPFL reconstruction and TTO is an effective alternative option for the treatment of PFI with satisfactory patient outcomes.[11] Given that greater than 60% of this study's cohort had moderate to severe trochlear dysplasia suggests a complex interaction exists between anatomic risk factors and shows surgical decision making is not based on one singular measure.

Due to its retrospective nature, this study has inherent limitations. Surgical indications were at the discretion of the treating surgeon, each of whom may have integrated other clinical and radiographic factors into their decision-making for TTO use. While TT-TG, CDI, and trochlear dysplasia classification are the most commonly cited factors impacting surgical decision-making for PFI, the application of such measures is varied across surgeons and institutions with many surgeons relying on their experience and comfort level when pursuing surgical intervention.[12,13] Novel methods of measuring patellar lateralization and trochlear morphology were not included in this study, but may have impacted surgical decision making in this cohort.[6,14,15]

Conclusion

In this large, multicenter cohort of adolescents and young adults undergoing TTO, the mean preoperative TT-TG distance was observed to be less than traditional indications of 20mm. TT-TG distances were not significantly different between different trochlear dysplasia classifications or patellar heights implying a multidimensional decision-making process. Further work is needed to determine the patient characteristics and other radiographic factors contributing to surgeons utilizing a lower radiographic threshold for TTO in adolescents through comparison with patients treated with MPFL reconstruction alone.

References

1. Fithian DC, Paxton EW, Stone ML, *et al.* Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med.* 2004 Jul;32(5):1114–21.

2. Sillanpää P, Mattila VM, Iivonen T, *et al.* Incidence and risk factors of acute traumatic primary patellar dislocation. *Med Sci Sports Exerc.* 2008 Apr;40(4):606–11.

3. Grimm NL, Lazarides AL, Amendola A. Tibial Tubercle Osteotomies: a Review of a Treatment for Recurrent Patellar Instability. *Curr Rev Musculoskelet Med.* 2018 Jun;11(2):266–71.

4. Leite CBG, Santos TP, Giglio PN, *et al.* Tibial Tubercle Osteotomy With Distalization Is a Safe and Effective Procedure for Patients With Patella Alta and Patellar Instability. *Orthop J Sports Med.* 2021 Jan;9(1):2325967120975101.

5. Dejour H, Walch G, Nove-Josserand L, *et al.* Factors of patellar instability: an anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc.* 1994;2(1):19–26.

6. Weltsch D, Chan CT, Mistovich RJ, *et al.* Predicting Risk of Recurrent Patellofemoral Instability With Measurements of Extensor Mechanism Containment. *Am J Sports Med.* 2021 Mar;49(3):706–12.

7. Elias JJ, Soehnlen NT, Guseila LM, *et al.* Dynamic tracking influenced by anatomy in patellar instability. *Knee.* 2016 Jun;23(3):450–5.

8. Pruneski J, O'Mara L, Perrone GS, *et al.* Changes in Anatomic Risk Factors for Patellar Instability During Skeletal Growth and Maturation. *Am J Sports Med.* 2022 Jul;50(9):2424–32.

9. Yeoh CSN, Lam KY. Tibial tubercle to trochlear groove distance and index in children with one-time versus recurrent patellar dislocation: a magnetic resonance imaging study. *J Orthop Surg.* 2016 Aug;24(2):253–7.

10. Dickens AJ, Morrell NT, Doering A, *et al.* Tibial tubercle-trochlear groove distance: defining normal in a pediatric population. *J Bone Joint Surg Am.* 2014 Feb 19;96(4):318–24.

11. Allen MM, Krych AJ, Johnson NR, *et al.* Combined Tibial Tubercle Osteotomy and Medial Patellofemoral Ligament Reconstruction for Recurrent Lateral Patellar Instability in Patients With Multiple Anatomic Risk Factors. *Arthroscopy.* 2018 Aug;34(8):2420–6.e3.

12. Liu JN, Steinhaus ME, Kalbian IL, *et al.* Patellar Instability Management: A Survey of the International Patellofemoral Study Group. *Am J Sports Med.* 2018 Nov;46(13):3299–306.

13. Erickson BJ, Nguyen J, Gasik K, *et al.* Isolated Medial Patellofemoral Ligament Reconstruction for Patellar Instability Regardless of Tibial Tubercle-Trochlear Groove Distance and Patellar Height: Outcomes at 1 and 2 Years. *Am J Sports Med.* 2019 May;47(6):1331–7.

14. Mistovich RJ, Urwin JW, Fabricant PD, *et la.* Patellar Tendon-Lateral Trochlear Ridge Distance: A Novel Measurement of Patellofemoral Instability. *Am J Sports Med.* 2018 Dec;46(14):3400–6.

15. Stepanovich M, Bomar JD, Pennock AT. Are the Current Classifications and Radiographic Measurements for Trochlear Dysplasia Appropriate in the Skeletally Immature Patient? *Orthop J Sports Med.* 2016 Oct;4(10):2325967116669490.