Suture anchor fixation of displaced tibial eminence avulsion fracture in children

Elsayed Elforse, Ayman El-Tabbaa

Department of Orthopedic Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt

Correspondence to ElSayed Elforse, MD, Department of Orthopedics, Tanta School of Medicine, Tanta University, Tanta 315511, Egypt Tel: +20 128 808 8078; E-mail: eelforse@gmail.com

Received: 07-Nov-2023
Revised: 18-Nov-2023
Accepted: 18-Nov-2023
Published: 12-Feb-2024

The Egyptian Orthopaedic Journal 2024, 59:49–55

Background
Avulsion fractures of the tibial eminence during childhood are infrequent yet significant knee injuries. Given that the injury is equivalent to a rupture of the anterior cruciate ligament. The treatment strategy necessitates anatomic reduction to reestablish joint stability and reduce the risk of anterior impingement and flexion deformity. The aim of the study was to evaluate short-term results of arthroscopyassisted suture anchor fixation of tibial eminence avulsion in children.
Methods
This study included 11 injured children with type III avulsion tibial eminence. The average age was 8.55 years. The study included nine boys and two girls. The mechanism of trauma was bicycle accident in seven children, twisting injury in two children, falling downstairs in one child, and jumping from a height in one case.
Results
All patients were able to return to their everyday activities within 6 months following the injury. The range of motion at the end of follow up was full in 10 (90.9%) patients and functional range in one (9.1%) patient. The knee stability was excellent by clinical examination.
Conclusion
The successful application of this approach in preserving knee function following type III avulsion tibial eminence in pediatric patients has been demonstrated.

Keywords:
arthroscope, avulsion tibial eminence, children, fixation, suture anchor

Egypt Orthop J 2024, 59:49–55

1110-1148

Introduction

The tibial eminence is the anatomical location where the anterior cruciate ligament (ACL) is attached. The ACL is recognized as one of the ligaments in the knee that is most commonly subjected to injury. The occurrence of tibial spine injury in pediatric patients is comparable to the occurrence of ACL rupture in adult individuals. The occurrence of tibial spine fractures is considered to be infrequent, with a reported incidence rate of merely three cases per 100 000 instances of pediatric fractures. This type of injury is most commonly observed in children aged between 8 and 17 years, reaching its highest occurrence during this age range. Due to the incomplete calcification of the intercondylar eminence in pediatric individuals, it is more susceptible to injuries in comparison to the ACL [1].

During adolescence, after the process of calcification reaches completion, the ligament itself becomes the vulnerable area that is susceptible to injury. Nevertheless, it is important to note that the occurrence of eminence fractures remains very infrequent, accounting for ∼14% of all ACL injuries. These fractures typically arise in instances of extremely high-energy traumas, such as knee joint dislocations [2].

The full understanding of the injury's process remains unclear. Fractures commonly arise from hyperextension, which can be attributed to incidents such as falls or jumps from high surfaces, sports-related injuries, and motor vehicle accidents involving the extension of the knee joint [2].

Furthermore, the pioneering work of Meyers and McKeever [3] marked the initial documentation of numerous cases. Their comprehensive analysis encompassed a total of 45 cases, of which 35 involved children.

In instances of undisplaced, type I fractures, it is advisable to proceed with conservative treatment, which involves the application of an above knee cast or bracing for a duration of 4–6 weeks [4].

The operative treatment of type II fractures characterized by partial displacement is advised in cases when conservative treatment fails, resulting in nonunion, instability, or anterior knee impingement [5].

Fractures classified as type III/A (displaced), type III/B (displaced and rotated), and type IV (comminuted) typically necessitate surgical intervention [6].

Several different techniques for fixing tibial eminence fractures have been documented, such as the use of Herbert screws, K-wires, and metal or fiberwire cerclages. These procedures have demonstrated favorable outcomes. However, there remains a lack of agreement regarding the optimal fixation method. The user did not provide any text to rewrite [7].

However, these techniques are not free of complications including nonunions, loss of reduction, extension lag due to remaining intraarticular hardware, injury of the physis, residual laxity, or irritation and pain from retained hardware [8].

Violating the physis carries the risk of growth disturbances [9].

The physeal-sparing arthroscopic method with nonabsorbable sutures inserted extraosseously was introduced by Hirschmann *et al.* [10] in their study. Fixation occurs at a location that is situated beyond the growth plate. This procedure bypasses the physeal plate, although it still results in the presence of nonabsorbable material within and surrounding the knee (specifically, a screw), which has the potential to give rise to significant complications.

We think of alternative method of fixation of the tibial eminence fracture using suture anchor to avoid making transphyseal tunnels and passing sutures as Hirschmann *et al.* [10] proposed their physeal sparing technique. Up to our knowledge this is the first report about using suture anchor fixation in tibial eminence fracture.

Patients and Methods

This is a retrospective case series study was carried out on 11 injured children having tibial eminence fracture confirmed preoperatively by plain radiographs (lateral and frontal view) treated with arthroscopically assisted reduction and fixation of tibial eminence avulsion using suture anchor (Tylpar NO 5.0 mm, double loaded).

Exclusion criteria

Exclusion criteria included any previous knee surgery, systemic diseases, associated ligamentous injury, associated meniscal injury, associated chondral lesions, infection in the knee, anatomic meniscal variants (complete or incomplete discoid meniscus), and age over 18 years. This study was carried out after written consents from the parents and ethical committee approval with approval code 36264PR432/11/22.

Preoperative assessment

On admission, physical examinations and conventional radiographs (anteroposterior and lateral views) were performed.

In many cases, the fracture could only be observed on lateral views. Nevertheless, the radiograph images were reliable on the detection of both the undisplaced and the partially displaced fractures. The fractures were classified based on the Meyers and McKeever system.

Preoperative MRI to exclude associated injuries also preoperative computed tomography if conventional radiograph did not clearly detect the size of the fragment.

Operative technique

Under general anesthesia, patients are positioned in supine position. A tourniquet is applied, after draping knee is positioned in 90-degree flexion, standard high anterolateral viewing portal is applied followed by low anteromedial working portal.

With the use of motorized shaver hematoma is evacuated with debridement of any debris. Partial release of intermeniscal ligament is done if it is interposed in the fracture site followed by clearance of the anterior aspect of the fragment and refreshing of the bed.

High anteromedial portal is created for insertion of suture anchor, a titanium 5 mm double-loaded suture is inserted in the center of the avulsed fragment and advanced to be flushed with the fracture crater to allow reduction of the fragment, the application must be applied perpendicular to the fragment to insure central positioning in the physis, intraoperative image intensifier is used to avoid crossing of the physeal plate to avoid physeal injury.

One limb of the suture strands of the anchor sutures is retrieved from under surface of the avulsed fragment anteriorly, knee is moved from 90-degree flexion to 30 degrees, sliding knot is applied using this limb with the other limb of the same strand to allow reduction of the anterior elevation of the fragment with application of the probe to insure anatomical position of the fragment.

Knee is positioned in 90-degree flexion, shuttle suture is passed in the mid-substance of ACL using a lasso suture passer. One limb of the remaining strand is shuttled through the shuttle suture through the substance of ACL, sliding knot is applied to add more secure fixation through the fibers of ACL.

Cycles of knee flexion and extension to test stability of the fragment and ensure that no impingement with the roof of intercondylar notch.

Postoperative follow up

Following the operation, a long plaster splint was applied in the position of a 20-degree flexion until wound healing with range of motion (ROM) exercises from 0 to 60 degrees for 2 weeks. After removing the splint fixation, increase gradually both active and passive exercises two to three times a week and a partial weight bearing was allowed from the postoperative fourth week. The full weight bearing of the operated joint was allowed after the sixth postoperative week. Follow-up examinations were performed monthly for 6 months, then in every 3 months for a year postoperatively; comparing the functional and radiological results of the operatively and conservatively treated groups.

Stability of the knee joint was confirmed by physical examination: Lachmann, anterior drawer and Pivot shift tests were performed. The functional outcome was evaluated by using the Lysholm functional scale [11].

Plain radiographs (frontal and lateral views) were performed at 6 weeks and 3 months postoperatively to assess fracture healing (Figs 1–5).

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package, version 20.0. (IBM Corp., Armonk, New York, USA). Categorical data were represented as numbers and percentages. Quantitative data were expressed as range (minimum and maximum), mean, SD, and median.

Results

A total of 11 patients were treated with our arthroscopy-guided suture anchor fixation method. The average age was 8.55 years. Nine boys and two girls were among the patients.

The cause of the injuries was usually related to sport activities. In seven cases, the injury was caused by bicycle accident, in two cases by twisting, in one case by falling downstairs, and in one case jumping from a certain height.

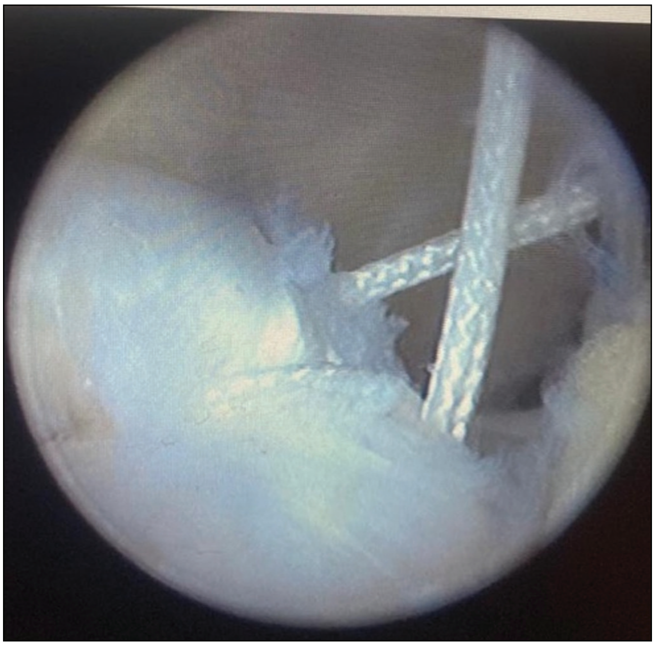
All the operations were performed using the arthroscopy-guided suture anchor fixation method.

Ten patients were able to return to their every-day activities within 6 months following the injury.

Figure 1

Plain radiograph 3-month postoperative show complete radiological healing with good reduction of the eminence fragment

Figure 2

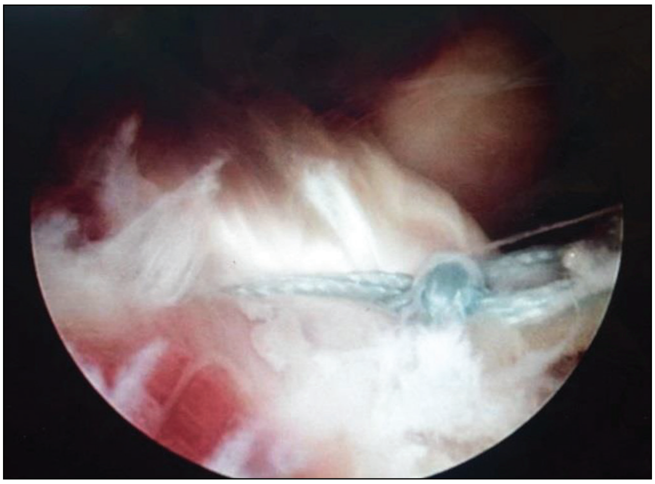


Passing sutures through midsubstance of ACL. ACL, anterior cruciate ligament

Figure 3

Preoperative computed tomography show displaced tibial eminence avulsion fracture

Figure 4



Final arthroscopic appearance

The ROM of the injured knee joint was full in 10 (90.9%) patients and functional in one (9.1%) patient. The clinical examinations showed joint stability (Table 1).

Discussion

An avulsion fracture of the tibial eminence is a relatively infrequent and classified as a significant injury to the knee joint [2].

The objective of this study was to assess the efficacy of utilizing an arthroscopically positioned suture anchor

Figure 5

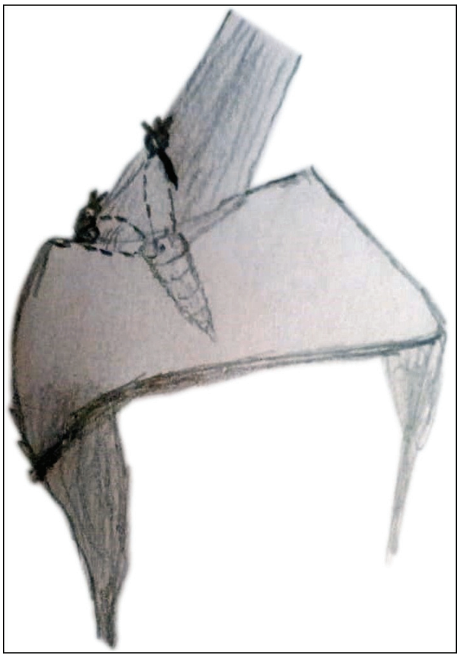


Diagram showing the technique, anterior sliding note for reduction of anterior elevation of the fragment, the second sliding note is applied in the substance of ACL. ACL, anterior cruciate ligament

for the repair of tibial eminence fractures in pediatric patients.

This study was carried out on 11 injured children. All the operations were performed using the arthroscopy-guided suture anchor fixation method. The average age was 8.55 years. Nine boys and two girls were among the patients.

In their study, Wiegand *et al.* [6] used the arthroscopy-guided Herbert-screw fixation approach to treat a cohort of eight patients. The mean age of was 12.5 years. There were a total of six male individuals and two female individuals included within the patient population.

The cause of the injuries was always related to some kind of sport activities. In seven cases, the injury was caused by bicycle accident, in two cases by twisting, in one case by falling downstairs, and in one case jumping from a certain height.

In addition, Wiegand *et al.* [6] found that five injuries were attributed to bicycle accidents, three injuries were attributed to skin accidents, two injuries were attributed to football accidents, and two injuries were attributed to leaping from a specific height.

Ten patients were able to return to their every-day activities within 6 months following the injury. Also, Wiegand *et al.* [6] found that all patients were able to

Table 1 Distribution of the studied cases according to different parameters (*N*=11)

	n (%)
Age (years)	
Mean±SD	8.55±1.57
Median (minimum–maximum)	8 (6–11)
Sex	
Male	9 (81.8)
Female	2 (18.2)
Type of trauma	
Bicycle	7 (63.6)
Falling downstairs	1 (9.1)
Falling from height	1 (9.1)
Twisting	2 (18.2)
Time from trauma to surgery	
Mean±SD	5.36±2.77
Median (minimum–maximum)	4 (3–11)
Side	
Right	6 (54.5)
Left	5 (45.5)
Duration of follow up (months)	
Mean±SD	5.73±2.10
Median (minimum–maximum)	6 (3–9)
Time to radiographic healing (weeks)	
Mean±SD	6.55±0.93
Median (minimum–maximum)	6 (6–8)
Return to sports	
Positive	10 (90.9)
Negative	1 (9.1)
Time to RTS (months)	
Mean±SD	3.91±1.14
Median (minimum–maximum)	4 (3–6)
Postoperative elevation of the fragment (mm)	
Mean±SD	0.73±0.90
Median (minimum–maximum)	0 (0–2)
Range of motion	
Full	10 (90.9)
Functional	1 (9.1)
Lachman	
Stable	11 (100.0)

return to their every-day activities within 6 months following the injury.

The ROM of the injured knee joint was full in 10 (90.9%) patients and functional in one (9.1%) patient. Wiegand *et al.* [6] found that the ROM of the injured knee joint was identical with healthy side, 6 weeks following treatment in the operative group.

The clinical examinations showed joint stability. Wiegand *et al.* [6] did not show joint instability in those patients who suffered type I fractures. In the three cases of the type II fractures, anterior drawer +, Lachmann +, and Pivot shift 0 deviations were observed. In all of the five patients suffering type III fractures, instability of the knee joint was demonstrated. In the most severe two cases, anterior drawer +++, Lachmann +++, and Pivot shift ++were observed, while in the other three cases anterior drawer++, Lachmann++, 0 and Pivot shift + or 0 were found, respectively.

In their study, Hunter and Willis [12] conducted a review of the outcomes observed in a cohort of 17 patients diagnosed with Meyers and McKeever type II or III fractures of the tibial eminence. The patients were treated using either arthroscopic suture or screw fixation techniques. The researchers conducted an assessment on a diverse group of individuals spanning a greater age range (mean: 26.6 years, ranging from 7.5 to 60.1 years). No statistically significant changes were observed in the outcomes when comparing the use of arthroscopic sutures with screw fixation. In relation to category age, it was observed that younger patients exhibited considerably higher functional scores. Significantly, in 10 instances, the intermeniscal ligament was found to be positioned between the avulsed fracture and the tibia. Consequently, it was necessary to either retract or excise the ligament prior to the reduction of the fracture.

Senekovic and Veselko [9] conducted a retrospective study that showcased favorable therapeutic outcomes in the management of intercondylar eminence fractures of the tibia. This was achieved through the utilization of arthroscopically inserted cannulated screws or cannulated screws with washers. This method facilitated prompt weight bearing for the individuals. In contrast to the aforementioned approach, the metal implants were extracted in all patients except for one.

The average operative time was 51.8 min, in study done by Li and collegaues which compare double-row and transosseous anchor knot fixation techniques with suture anchor. The average operative time was 81.06 min in double row fixation group and 84.89 min in anchor knot fixation group [13].

Various varieties of absorbable pins may serve as a viable substitute for the utilization of screw fixations. In a study conducted by Shepley [14], a total of five patients with type III tibial spine fractures were effectively treated. The average age of these patients was 15 years. The treatment approach employed by Shepley involved the utilization of arthroscopic reduction and internal stabilization techniques, utilizing absorbable pins. All patients successfully attained complete ROM and demonstrated radiographic evidence of fracture consolidation.

In a clinical trial conducted by Delcogliano *et al.* [15], a comparison was made between PDS I 2.0 sutures and nonresorbable No. 2 Ethibond sutures for the treatment of tibial eminence fractures in adult patients. Both cohorts exhibited favorable clinical and functional outcomes.

Schneppendahl *et al.* [16] conducted a biomechanical cadaver study to compare the mechanical properties of Vicryl No. 5 and PDSII sutures with FibreWire. Vicryl exhibited biomechanical qualities that were comparable to those of FiberWire. While FibreWire demonstrated a higher ultimate failure load, Vicryl No. 5 exhibited comparable results during cycle testing conditions. The researchers expressed a preference for Vicryl as a potential substitute for nonabsorbable sutures, while they did according to Wiegand *et al.* [6]. The utilization of Herbert screw fixation has demonstrated efficacy in the management of displaced tibial spine fractures. This approach offers notable stability and effectively maintains the functionality of the affected knee in the immediate postoperative period. not attribute the same level of effectiveness to PDS II.

Using single suture anchor make this technique cost effective in relation to other methods of fixation like using screw fixation, and transosseus suture fixation.

Brunner *et al.* [17] conducted a study to evaluate the efficacy and safety of a new surgical technique for treating displaced tibial eminence fractures. This technique involved the use of absorbable sutures and distal bone bridge fixation. The researchers have arrived at the determination that the utilization of absorbable sutures and distal bone bridge fixation in the mending of extraphyseal tibial eminence produces similar rates of radiographic and clinical healing after a period of 3 months following the surgical procedure, in comparison to the employment of nonabsorbable sutures fastened around a screw. Additionally, this strategy obviates the need for additional hardware extraction.

In comparison to the Herbert screw fixation, the new technique by having sutures can better control the fragment and change the points of suture piercing the ACL attachment if needed till reaching the ideal reduction. Also the pullout strength is better for the sutures than the screws especially in cases of shallow spine fractures without big cancellous sbuchondral bone purchase. The anchor being central theoretically has low risk of physeal injury even if reaches the physeal plate in comparison to the eccentrically positioned tunnels for suture or cerclage fixation.

Conclusion

The arthroscopic-guided methods should be preferred, with the choice of suture fixation that provides the most stable fixation. The method developed and applied by our team differs from the earlier surgical solutions. We have demonstrated that our method used with the right indication, adequate experience, and carefulness could successfully be applied to preserve the function of the knee after severe avulsion tibial eminence in children [18].

One of the potential limitations of our study is the relatively low number of cases; however, it is known that tibial spine fractures are uncommon types of injuries.

Another limitation of the study is that only conventional radiographs or in a few cases, computed tomography scan were included into the imaging preoperative protocol. However, Aderinto *et al.* [19] reported that results with the treatment of tibial spine fractures in children (or in adults) have also utilized only conventional radiographs and the arthroscopy itself as imaging diagnostics, especially putting in mind the hazards of computed tomography in pediatric population so not an essential step unless indicated to clarify the fracture classification if operative indication is doubtful. This a retrospective study with short period of follow up, other randomized controlled comparative study with lager sample size and longer period of follow up is recommended.

Financial support and sponsorship
Nil.

Conflicts of interest
No conflict of interest.

References

1. Kocher MS, Mandiga R, Klingele K, Bley L, Micheli LJ. Anterior cruciate ligament injury versus tibial spine fracture in the skeletally immature knee: a comparison of skeletal maturation and notch width index. J Pediatr Orthop 2004; 24:185–188.
2. Kendall NS, Hsu SY, Chan KM. Fracture of the tibial spine in adults and children. A review of 31 cases. J Bone Joint Surg Br 1992; 74:848–852.
3. Meyers MH, McKeever FM. Fracture of the intercondylar eminence of the tibia. J Bone Joint Surg Am 1970; 52:1677–1684.
4 - Reynders P, Reynders K, Broos P. Pediatric and adolescent tibial eminence fractures: arthroscopic cannulated screw fixation. J Trauma 2002;53:49–54.
5. Mylle J, Reynders P, Broos P. Transepiphysial fixation of anterior cruciate avulsion in a child. Report of a complication and review of the literature. Arch Orthop Trauma Surg 1993; 112:101–103.
6. Wiegand N, Naumov I, Vamhidy L, Not LG. Arthroscopic treatment of tibial spine fracture in children with a cannulated Herbert screw. Knee 2014; 21:481–485.
7. Herman MJ, Martinek MA, Abzug JM. Complications of tibial eminence and diaphyseal fractures in children: prevention and treatment. Instr Course Lect 2015; 64:471–482.
8. Senekovic V, Balazic M. Bioabsorbable sutures versus screw fixation of displaced tibial eminence fractures: a biomechanical study. Eur J Orthop Surg Traumatol 2014; 24:209–216.

9. Senekovic V, Veselko M. Anterograde arthroscopic fixation of avulsion fractures of the tibial eminence with a cannulated screw: five-year results. Arthroscopy 2003; 19:54–61.
10. Hirschmann MT, Mayer RR, Kentsch A, Friederich NF. Physeal sparing arthroscopic fixation of displaced tibial eminence fractures: a new surgical technique. Knee Surg SportsTraumatolArthrosc 2009; 17:741–747.
11. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 1982; 10:150–154.
12. Hunter RE, Willis JA. Arthroscopic fixation of avulsion fractures of the tibialeminence: technique and outcome. Arthroscopy 2004; 20:113–121.
13. Li J, Liu C, Li Z, Fu Y, Yang Y, Zhang Q. Arthroscopic fixation for tibial eminence fractures: comparison of double-row and transosseous anchor knot fixation techniques with suture anchors. Med Sci Monit 2018; 24:7348–7356.
14. Shepley RW. Arthroscopic treatment of type III tibial spine fractures using absorbable fixation. Orthopedics 2004; 27:767–769.
15. Delcogliano A, Chiossi S, Caporaso A, Menghi A, Rinonapoli G. Tibial intercondylar eminence fractures in adults: arthroscopic treatment. Knee Surg Sports Traumatol Arthrosc 2003; 11:255–259.
16. Schneppendahl J, Thelen S, Twehues S, Eichler C, Betsch M, Windolf J, *et al*. The use of biodegradable sutures for the fixation of tibial eminence fractures in children: a comparison using PDS II, Vicryl and FiberWire. J Pediatr Orthop 2013; 33:409–414.
17. Brunner S, Vavken P, Kilger R, Vavken P, Kilger R, Vavken J, *et al*. Absorbable and non-absorbable suture fixation results in similar outcomes for tibial eminence fractures in children and adolescents. Knee Surg Sports Traumatol Arthrosc 2016; 24:723–729.
18. Kim JI, Kwon JH, Seo DH, Soni SM, Muñoz M, Nha KW. Arthroscopic hybrid fixation of a tibial eminence fracture in children. Arthrosc Tech 2013; 2:e117–e120.
19. Aderinto J, Walmsley P, Keating JF. Fractures of the tibial spine: epidemiology and outcome. Knee 2008; 15:164–167.