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Research Article | Araştırma Makalesi

EVALUATION OF THE ENDOBUTTON TECHNIQUE IN THE TREATMENT OF PEDIATRIC TIBIAL EMINENCE FRACTURES

PEDİATRİK TİBİAL EMİNENCE KIRIKLARININ TEDAVİSİNDE ENDOBUTTON TEKNİĞİNİN DEĞERLENDİRİLMESİ

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ABSTRACT

Objective: The aim of this study was to evaluate the effectiveness of the EndoButton technique in the treatment of tibial eminence (intercondylar eminence) fractures in pediatric patients with open epiphyseal plates under the age of 18.

Methods: This retrospective study included 21 pediatric patients. According to the Meyers and McKeever classification, 52.4% of the fractures were classified as Type II and 47.6% as Type III. All patients underwent arthroscopic fixation using the EndoButton technique.

Results: Postoperative follow-up demonstrated a significant improvement in functional outcomes. The mean Lysholm Knee Score (LKS) increased from 48.6 preoperatively to over 96 at both 6 and 12 months postoperatively. No major complications were observed, and all patients returned to their previous activity levels.

Conclusion: The EndoButton technique offers strong fixation, facilitates early mobilization, and reduces the risk of knee stiffness, resulting in low complication rates and high functional recovery. Importantly, no adverse effects on the growth plate (physis) were observed. Despite limitations such as small sample size, retrospective design, and a heterogeneous patient group, the long-term follow-up results indicate that the EndoButton technique is a safe and effective method for treating pediatric tibial eminence fractures.

Keywords: Tibial Emnensia Fracture, Pediatric, Anterior Cruciate Ligament

ÖZ

Amaç: Bu çalışmanın amacı, açık epifiz plaklarına sahip 18 yaş altı pediatrik hastalarda tibial eminens (interkondiler eminens) kırıklarının tedavisinde EndoButton tekniğinin etkinliğini değerlendirmektir.

Yöntem: Retrospektif olarak planlanan bu çalışmaya toplam 21 pediatrik hasta dahil edilmiştir. Meyers ve McKeever sınıflamasına göre hastaların %52,4'ü Tip II, %47,6'sı ise Tip III kırık grubunda yer almaktadır. Tüm hastalara artroskopik olarak EndoButton yöntemiyle tespit uygulanmıştır.

Bulgular: Postoperatif takiplerde fonksiyonel sonuçlarda anlamlı bir iyileşme gözlemlenmiştir. Hastaların ortalama Lysholm Diz Skoru (LKS), ameliyat öncesinde 48,6 iken, postoperatif 6. ve 12. aylarda 96'nın üzerine çıkmıştır. Hiçbir hastada ciddi komplikasyon izlenmemiş ve tüm hastalar önceki fiziksel aktivite düzeylerine geri dönmüştür.

Sonuç: EndoButton tekniği, güçlü tespit sağlaması, erken mobilizasyona olanak tanıması ve diz sertliğini önlemesi sayesinde düşük komplikasyon oranı ve yüksek fonksiyonel iyileşme sağlamaktadır. Ayrıca, büyüme kıkırdağı (fizis) üzerinde olumsuz bir etkisi gözlemlenmemiştir. Her ne kadar çalışmanın küçük örneklem büyüklüğü, retrospektif tasarımı ve heterojen hasta grubu gibi bazı sınırlılıkları bulunsa da uzun dönem takip sonuçları bu tekniğin pediatrik tibial eminens kırıklarının tedavisinde güvenli ve etkili bir yöntem olduğunu göstermektedir.

Anahtar Kelimeler: Tibial Emnensia Kırığı, Pediatrik, Ön Çapraz Bağ

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Introduction

The tibial eminence fracture represents an avulsion fracture that transpires at the tibial attachment locus of the anterior cruciate ligament.[1,2] The nomenclatures tibial eminence fracture (TEF) and tibial spine fracture (TSF) are frequently employed interchangeably within the literature.[3] Although the underlying mechanism of this particular fracture remains inadequately elucidated, numerous studies have investigated the influence of the geometric configuration of collagen fibers within the anterior cruciate ligament on the trauma mechanism.[4]

The prevalence of tibial eminence fractures within the population has been documented as occurring at a rate of 3 per 100,000.[5,6] Such fractures have been observed to be more prevalent among individuals possessing an immature skeletal framework when contrasted with those exhibiting a mature skeletal structure. The primary rationale for this observation is that the incompletely ossified composition of the tibial eminence in pediatric patients typically demonstrates structural failure at an earlier stage than the associated connective tissue.[2,3] It has been indicated that this type of fracture is most frequently encountered in the pediatric demographic, specifically within the age range of 8 to 14 years, and it has been reported to constitute approximately 2% to 5% of injuries associated with knee effusion.[7-9] Consequently, a meticulous assessment of this fracture in light of the potential for misdiagnosis is paramount.[5]

Pringle et al. originally described tibial eminence fracture in 1907.[10] Based on the degree of displacement, Meyers and McKeever (1959) classified the fractures into three types: Type 1, Type 2, and Type 3. Fractures classified as Type 1 have limited displacement, Type 2 fractures only have anterior separation and posterior bone contact, and Type 3 fractures are fully displaced.[3,11] Type 4, which was added later in 1977, describes fractures that are totally displaced and comminuted into tiny fragments.[12] While surgical therapy is advised for the other types of fractures, nonoperative treatment is typically used for Type 1 fractures.[3,13,14] Tibial eminence fractures are treated with both open and arthroscopic techniques.[3] The use of arthroscopic fixation has grown in favor in the current era, and it has proven beneficial in treating meniscal or chondral lesions as well as intermeniscal ligament entrapment that may be linked to fractures.[1,15,16]

Anatomical reduction and internal fixation are advised for displaced fractures to preserve the integrity of the femur-UCL-tibia complex and to avoid mechanical block in knee extension, even though there is disagreement in the literature about closed and open treatment, internal fixation methods, and postoperative management for tibial eminence fractures in the pediatric age group.[17] Early postoperative motion may be possible because of the material selection for fixation, which may lessen postoperative problems including postoperative arthrofibrosis and knee motion limitation.[17,18]

One benefit of this approach is that, because there are no sutures involved, the anterior cruciate ligament's biomechanical and proprioceptive integrity is maintained. This is crucial for maintaining proprioception and avoiding disorders of the anterior cruciate ligament.[15-17]

According to the literature, sutures, K-wires, screws, cerclage cables, suture anchors, and the EndoButton fixation device are the most often utilized fixation methods for tibial eminence fractures.[2] In order to preserve the growth plate (physes) and reduce the possibility of iatrogenic development disturbance, it is advised that pediatric patients avoid this location while fixing tibial eminence fractures.[17,19] When comparing the use of screws and sutures, some studies found that the results were equivalent,[20,21] however other studies found that all constructs with screw fixation had lower tensile strength and failed in repeated loading cycles.[17] The literature does not, however, agree on the ideal kind of fixation.[2]

For the treatment of tibial eminence fractures, the EndoButton fixation device seems to be a suitable choice. However, more study is required to clarify this issue because there aren't many studies on this technique in youngsters.[19,22] The purpose of this study was to assess the EndoButton technique's effectiveness in treating pediatric patients.

Methods

The clinical research ethics committee of the Kastamonu University gave its approval for this retrospective study on December 29, 2022, and decision number 25. The study comprised patients under the age of eighteen who had been diagnosed with a tibial spine fracture (TSF) between November 2014 and September 2019 at the Department of Orthopedics and Traumatology at the Kastamonu University Faculty of Medicine, had open epiphyses, and had received at least five years of follow-up. Direct radiographs, radiologic pictures, physical tests, and demographic information were gathered from the PACS system and hospital records. Exclusion criteria; were as follows: (1) patients older than 16 years; (2) patients without 12-month follow-up after surgery; (3) fractures in other extremities in addition to tibial eminentia fracture; (4) patients developing surgical site infection or endobutton perforator after surgery. The Meyers and McKeevers classification was used to analyze each fracture.[11] The study only included individuals who received arthroscopy treatment utilizing the EndoButton approach and who were reassessed with arthroscopic findings. Potential problems following surgery were noted.

Surgical Technique

All procedures were performed under general anesthesia with the patient in the supine position. A tourniquet was applied in all cases to improve visualization and reduce intra-articular bleeding. Standard anteromedial and anterolateral portals were used for knee arthroscopy. When present, the ligamentum mucosum was excised to

optimize visualization. Initial arthroscopic debridement was performed to ensure adequate exposure of the fracture bed and fragment, and concomitant chondral or meniscal lesions were carefully assessed and treated as required. In most cases, the intermeniscal ligament was found to be interposed between the fracture fragments and was released using a probe.

The knee was flexed to approximately 45°, and the fracture fragment was gently depressed. In all patients, the tibial tunnel for the anterior cruciate ligament (ACL) was created using an ACL tibial aimer set at 55°. The intra-articular tip of the aimer was positioned at the center of the tibial eminence fragment, immediately anterior to the tibial attachment of the ACL. The tibial entry point was chosen on the medial cortex, medial to the tibial tubercle and at a more distal level relative to the joint line. The aimer angle was adjusted so that the tunnel originated from the anteromedial cortex, traversed a minimal segment of the proximal tibial apophysis, crossed a relatively central portion of the physis rather than the periphery, and exited at the center of the intercondylar eminence. In this way, the osseous structures around the tibial tubercle and apophysis were preserved as much as possible, and iatrogenic injury to the growth plate was minimized.

After passage of a 1.6-mm K-wire through the fracture fragment, the tibial tunnel was created with a 4.5-mm cannulated drill. A polydioxanone suture (PDS) was then passed through the fragment via this tunnel. Following retrieval of the PDS suture through the anteromedial portal, the EndoButton was loaded onto the avulsed fragment and drawn into position through the tibial tunnel, where it was secured to the neck of a 3.5-mm round-head screw placed anteromedially in the tibia. Anterior cruciate ligament tension was assessed with a probe, and anatomic reduction of the fracture was confirmed arthroscopically and with intraoperative fluoroscopy. At the end of the procedure, a drain was placed in the joint, and a long leg cast was applied with the knee maintained in 20° of flexion.

Postoperative Rehabilitation and Follow-up Protocol

During the first four weeks following surgery, patients were immobilized with a splint to promote soft tissue repair. Following this time, the splint was taken off, and partial load passive and active activities were initiated. Full load was administered during the sixth week, and controls were carried out every two months until the end of the six-month term. Follow-ups continued at 3-month intervals after the sixth month. During follow-up, the patients' radiologic and functional assessments were documented.

At six and twelve months after surgery, the patients' knee stability was assessed using the Lachman, anterior drawer, and pivot shift tests. Additionally, the patients' Lysholm knee scores were assessed based on their outcomes at six and twelve months. Limping, using support, locking, dislocation (the knee sliding forward), stair climbing, squatting, swelling, and pain are some of the factors that are included in this grading system.[23,24]

Results

Table 1 below provides a summary of the clinical and demographic information for the 21 patients that were part of this study. With a mean age of 10.3 ± 2.31 years (range 8-14 years), there were 15 male patients (71.4%) and 6 female patients (28.6%). Left knees accounted for 81% of the knee surgeries, while right knees made for 19%. Ten patients (47.5%) had Type III fractures and eleven patients (52.4%) had Type II fractures, based on fracture classification. None of the patients in the research experienced type IV fractures. Every patient received treatment using the arthroscopic EndoButton technique.

Table 1. Demographic and clinical data of the patients ıncluded in the study

Main data of the study		
Sex, n (%)	Men Women	15(71.4) 6 (28.6)
Age, mean ± SD	10,3±2,31	
Operated knee, n (%)	Right Left	4 (19) 17 (81)
Type of Fracture, n (%)	Type 2 Type 3	11(52.4) 10 (47.6)
Preope Month Lysholm Knee Score, mean ± SD	48.61±9.40	
Post Op 6. Month Lysholm Knee Score, mean ± SD	96.57± 3.31	
Post Op 12. Month Lysholm Knee Score, mean ± SD	96.80±3.37	

*Categorical data are presented as frequency (percentage), and numerical data are presented as mean ± standard deviation.

The intermeniscal ligament was found to be compressed between the fracture fragments in 14 individuals (66.6%), although there were no concurrent pathologies such as osteochondral damage or meniscal tears. During surgery, a hook was used to fix this, and the fracture line was anatomically decreased. Prior to and following surgery, there were no significant side effects, such as deep vein thrombosis, infection, or damage to the nerves or arteries.

All patients' anatomical reduction of the fracture line was confirmed by direct radiographs taken on the first postoperative day. No patient had any signs of infection, tibial eminence enlargement, malunion, or intra-articular impingement at the postoperative follow-up. Furthermore, radiologic assessments of the tibial fracture did not show any negative results.

All patients successfully returned to their pre-injury activity levels at 6 months postoperatively. At 6 and 12 months postoperatively, only 2 patients (9.5%) with Type III fractures had positive anterior drawer test and Lachman test. Otherwise, full extension and flexion ranges of motion were observed in all patients.

The Lysholm knee score in functional examinations was 48.61 ± 9.40 before surgery, 96.57 ± 3.31 at six months, and 96.80 ± 3.37 at twelve months. These data show that the surgical procedure is effective and produces excellent results. Although he had no complaints, the only patient who asked for the fixing material to be removed because of his beliefs had the treatment done arthroscopically.
High functional success rates and minimal complication rates were achieved in tibial eminence fractures treated with the arthroscopic EndoButton approach, according to the data described in Table 1 and the clinical results acquired. The EndoButton technique is a safe and efficient treatment option, according to this study.

Discussion

This study demonstrates that low complication rates and high functional recovery are achieved using the EndoButton system in the treatment of eminence fractures in children. The study supports the efficacy of the EndoButton method in this field, demonstrating that it is a clinically and radiologically effective and safe treatment method.
Although various materials have been used in the treatment of tibial eminence fractures, there are limited studies on EndoButton.[2,25] In 2005, Pape et al. proposed the use of arthroscopic EndoButton as an alternative treatment method. In an animal experiment by Hapa et al., it was shown that the treatment of eminensia fracture with EndoButton was stronger and more effective in terms of initial strength than suture or suture anchor.[26]
In skeletally immature patients, Memisoglu et al. reported that arthroscopic intra-articular button fixation yielded excellent mid- to long-term outcomes, with stable knees, no limb-length discrepancy, and high functional scores (mean Lysholm ≈ 95.7; IKDC ≈ 94.3) over an average 69-month follow-up, without routine need for implant removal, thereby supporting the safety and efficacy of button-based constructs in pediatric populations.[46]
The most important problems with this treatment method include the potential to cause premature closure of the physis or the possibility of impingement due to the presence of intra-articular metal.[27] In anterior cruciate ligament surgery in children, attention has been drawn to the risk of growth arrest due to tibial and femoral tunnels. It is known that the tibial tunnel is made between 6-10 mm and it is stated that the injury to the physique may be related to the size of the hole.[28-30]
Drill hole size is of great importance in EndoButton use, especially in tibial tunnel creation. In order to preserve the open physis in children, the holes passing through the physis should be of minimum diameter to prevent premature closure. In the literature, Sekiya et al.[27] used a 2.4 mm diameter drill hole and Yildirim et al.[22] used a 4.5 mm diameter drill hole. In our study, a tibial tunnel with a diameter of 4.5 mm was drilled and no evidence of trauma was found.
Our study includes one of the longest follow-up series in the literature with a follow-up period of at least 5 years. In the literature, it has been reported that there was no physeal growth plate closure after EndoButton treatment. Our long-term follow-up results support these findings.
The use of intra-articular fixation material with the EndoButton method may increase the risk of impingement and therefore removal of the material after union is recommended.[27] However, in this study, no patient developed intra-articular impingement caused by the material and removal was not required. Only one patient requested removal of the material voluntarily, and no evidence of impingement was found on second-look arthroscopy.
In this study, when clinical outcomes were analyzed, it was observed that Lysholm Knee Score (LKS) scores were above 90 after surgery. In our study, the LKS score increased from 48 before surgery to 96 after surgery using EndoButton. These results demonstrate that the EndoButton method is clinically successful.
Another complication reported with this technique is limitation of motion. Yildirim et al.[22] reported limitation of motion in four patients in their case series of 13 patients under 18 years of age. All movement limitation problems were resolved with physical therapy within two months during the postoperative rehabilitation period. Faivre et al.[35] also reported five complications in their case series, including arthrifibrosis and limitation of motion. After fracture reduction with other materials, limitation of motion was reported in 11.2%.[36] In our study, no limitation of motion was observed in any patient and all patients returned to their pre-traumatic condition. It is thought that the EndoButton holds the fracture fragments tightly with a large contact area, thus preventing knee stiffness by providing early motion.
When the clinical results were analyzed, it was observed that the Lysholm Knee Score (LKS) results were above 90 in the postoperative period. In the study by Huang et al.[37] the LKS score after arthroscopic suture fixation was recorded as 96 postoperatively while it was 38 preoperatively. Ahn et al.[38] reported a postoperative LKS score of 95.6 using pull-out suture technique. May et al.[39] increased the LKS score from 43 to 93 preoperatively using sutures and screws. In a meta-analysis comparing open and arthroscopic techniques, it was reported that the LKS score was 96 in open surgery and 91 in arthroscopic surgery.[40] However, EndoButton method was not included in these studies. Zhang et al.[34] reported the LKS score as 96 using EndoButton. In our study, the LKS score was 48 preoperatively and reached 96 postoperatively using EndoButton. These findings suggest that the EndoButton method provides similar and successful clinical results when compared with other techniques.
Sekiya et al.[27] recommended the use of superior antero-

lateral and superior medial portals in cases where fracture fragments are barely visible through conventional portals. Successful results have been

reported with the use of EndoButton as it provides stronger initial fixation and is sufficient for union.[19,26] Although there was a pediatric group in our study, a new portal was not needed, adequate visualization was provided with conventional portals and successful results were obtained.

Intervening soft tissues are among the main factors preventing reduction in tibial eminence fractures. Kocher et al.[1] reported that the intermeniscal ligament and meniscus were between the fracture fragments in 54% of patients. Hunter et al.[41] reported that the intermeniscal ligament entered the fracture site and prevented complete reduction in 59% of patients. In our study, it was observed that the intermeniscal ligament prevented reduction in 66.6% of the patients and complete reduction was achieved by correcting it with the help of a probe. This finding suggests that arthroscopy is effective in visualizing soft tissues.

In the literature, knee laxity is one of the most commonly reported complications in pediatric eminence fractures.[42] Smith et al.[44] found anterior knee laxity in all 15 treated pediatric patients and explained the cause as stretching of the anterior cruciate ligament before fracture. In the literature, it has been reported that knee laxity can be caused by inadequate reduction, pathologic laxity or failure of anatomical reduction.[45] In our study, only 9.6% patients had postoperative knee laxity. This low rate was attributed to the preservation of anterior cruciate ligament tissue and proprioception sensation during surgery.

The advantages of this technique include low morbidity, diagnosis and treatment of associated injuries, anatomical reduction of the fragments, short surgical time and early rehabilitation with full weight bearing. In addition, no damage to the cruciate ligament tissue and no need for implant removal are important advantages.

The study has several limitations. These include the relatively short follow-up period, small sample size, and retrospective design. Its single-center nature limits the generalizability of the findings. The use of a heterogeneous group without randomization reduces statistical power, and the absence of a control group precludes definitive conclusions. Moreover, because body mass index (BMI) and functional/activity-based parameters such as the Tegner score could not be reliably ascertained retrospectively, we were unable to analyze the relationship between clinical outcomes and body composition or activity level, which represents an important limitation. Nonetheless, given the retrospective design and limited sample size, we acknowledge that very subtle limb-length discrepancies or minimal fibrotic changes detectable only by advanced imaging may not have been fully excluded.

In conclusion, In this retrospective study, the treatment of Meyers-McKeever Type II and Type III tibial eminence fractures in pediatric patients with open epiphyseal plates using the arthroscopic EndoButton technique was comprehensively evaluated. In a series of 21 cases, radiological anatomical union was achieved in all cases, knee joint range of motion was preserved, and all patients were able to return to their pre-trauma physical activity levels. The Lysholm Knee Score, which was 48.6 on average before surgery, exceeded 96 at 6 and 12 months after surgery, demonstrating the high functional success of the technique. The absence of major complications such as deep vein thrombosis, infection, neurovascular injury, significant joint stiffness, or residual instability supports the safety profile of the method. No clinically significant leg length discrepancy, arthrofibrosis, or other major complications related to growth were observed in our study group during follow-up; however, we acknowledge that very slight limb length differences detectable only by advanced imaging methods cannot be completely ruled out.

The study findings are consistent with the advantages offered by EndoButton and other suspension fixation methods in the literature, such as strong mechanical stability, enabling early mobilization, and reducing intra-articular implant load. The location of the tibial tunnel away from the physis and the absence of intra-articular metal implants provide a significant advantage in the pediatric population by minimizing the risk of damage to the growth plate. Furthermore, the very low need for implant removal and the preservation of knee function in long-term follow-up make the EndoButton technique an important option, especially in pediatric patients who are athletes or who aim to return to high activity levels quickly.

However, the retrospective design of the study, the relatively small sample size, the absence of a control group, and the heterogeneous nature of the patient group are important factors that limit the generalizability of the results. Therefore, prospective, randomized, and multicenter studies comparing the EndoButton technique with different fixation methods (screws, sutures, suture anchors, etc.) in terms of functional outcomes, knee stability, long-term effects on the growth plate, and return-to-sport times are needed. Based on the current data, it has been concluded that the EndoButton technique can be recommended as a reliable and effective surgical option for the treatment of pediatric tibial eminence fractures due to its high functional success rate, low complication rate, and good physioprotective effect.

Ethics approval and consent to participate

The study was performed in accordance with the Declaration of Helsinki. The study was approved by the Institutional Review Board of Kastamonu University (B.30.2.ATA.0.01.00/3). Informed consent was obtained in writing from all participants prior to the study. For participants under 16 years of age, consent was provided by their parents or legal guardians.

Author contributions

RT; Study idea and design, methodology, surgical treatment oversight, supervision, and writing the first draft of the manuscript, MK, FU; Patient recruitment, data acquisition, perioperative and follow-up clinical assessments, and contribution to interpretation of

findings, GS, AEP; Data curation, statistical analysis, and interpretation of results; support in literature review, MT; Data acquisition, postoperative follow-up documentation, and data verification, RT, MK, FU, GS, AEP, MT; Critical revision of the manuscript, approval of the final version, and accountability for all aspects of the work.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interests
The authors declare no competing interests.

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