

Mid-term outcomes of arthroscopic suture fixation technique in tibial spine fractures in the pediatric population

✉ Ceyhun Çağlar, M.D.,¹ ✉ Hilal Yağar, M.D.,² ✉ Fahri Emre, M.D.,³ ✉ Mahmut Uğurlu, M.D.⁴

¹Department of Orthopaedics and Traumatology, Ankara City Hospital, Ankara-Turkey

²Department of Orthopaedics and Traumatology, Yozgat City Hospital, Yozgat-Turkey

³Department of Orthopaedics and Traumatology, Gülhane Training and Research Hospital, Ankara-Turkey

⁴Department of Orthopaedics and Traumatology, Ankara Yıldırım Beyazıt University Faculty of Medicine, Ankara-Turkey

ABSTRACT

BACKGROUND: Tibial spine fractures are avulsion injuries that are a similar mechanism to anterior cruciate ligament rupture. Although its incidence is not very common, it can cause possible complications and permanent sequelae in the knee joint if not treated correctly. The aim of this study was to evaluate the mid-term results of the arthroscopic suture technique for tibial spine fractures in a pediatric population.

METHODS: Analyzed retrospectively were 28 patients who underwent the arthroscopic suture fixation technique at our clinic, due to type 2 (with >5 mm displacement), 3 and 4 tibial spine fractures, between January 2013 and December 2017. The demographic features, injury mechanism, fracture classification, mean follow-up time, radiographic healing time, return to activity time, instability examination, joint range of motion (ROM), and knee injury and Osteoarthritis Outcome Score (KOOS) parameters of the patients were evaluated both clinically and functionally.

RESULTS: The mean age of the patients was 14.2. In addition, 17 patients were male (61%) and 20 had a healthy body mass index (71%). According to the modified Meyer and McKeever classification, type 2 tibial spine fracture was most common. The mean follow-up period was 4.64 years and the mean radiological healing time was calculated as 2.17 months. Of these patients, 27 were fully functional in terms of ROM (96%). Secondary surgery was performed on 1 patient due to arthrofibrosis and severely limited ROM. The mean 6-month KOOS was 82.3, while the 12-month KOOS was 91.4 and the 24-month KOOS was 95.7. A significant difference was observed between these scores ($p=0.024$).

CONCLUSION: The outcomes of the arthroscopic suture technique for the treatment of tibial spine fractures in a pediatric population were both clinically and functionally satisfactory. Anatomic reduction and early rehabilitation increased the success rate in the treatment of these fractures. Longer follow-up will provide more information.

Keywords: Anterior cruciate ligament; arthroscopy; knee injury and Osteoarthritis Outcome Score; suture fixation; tibial spine.

INTRODUCTION

Tibial spine fractures are avulsion injuries caused by the anterior cruciate ligament (ACL) in the tibial intercondylar eminence.^[1] It is frequently seen in the pediatric population and occurs in approximately 3/100,000 children each year.^[2] It also constitutes 2–5% of knee injuries associated with effusion in the pediatric population.^[3]

The injury mechanism occurs simultaneously with external rotation or hyperextension of the tibia during forced knee flexion, similar to the ACL rupture mechanism.^[4] Falling while cycling, traffic accidents, and sports, such as football, rugby, and skiing, are the main causes of tibial spine fracture. In children, tibial eminence is usually not fully ossified, so an avulsion fracture occurs during injury rather than an ACL rupture.

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Address for correspondence: Ceyhun Çağlar, M.D.

Ankara Şehir Hastanesi, Ortopedi ve Travmatoloji Kliniği, Ankara, Turkey

Tel: +90 312 - 552 60 00 E-mail: ceyhun.caglar@hotmail.com

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The modified Meyer and McKeever classification system is used for the classification of tibial spine fractures and it is classified according to the degree of fracture displacement.^[4] Type 1 fractures are completely nondisplaced, type 2 fractures are partially displaced and the posterior cortex is intact, type 3 fractures are completely displaced, and type 4 fractures are displaced and tibial eminence is comminuted. While conservative treatment is generally sufficient in type 1 fractures, surgery comes to the forefront in all types 3 and 4 fractures, and in type 2 fractures with >5 mm displacement.^[5] Surgery should be performed quickly on patients who have decided to have surgery because delayed surgery causes an increased risk of knee arthrofibrosis.^[6]

The main goal of in-treatment is to heal the displaced part in its anatomical position. Thus, it is aimed to prevent the possible knee joint instability and extension limitation.^[7,8] In addition, if these fractures are not treated properly, many problems may occur, such as malunion, nonunion, quadriceps atrophy, retropatellar pain, arthrofibrosis, and disruption of the tibial growth plate.^[9-11]

Although many techniques have been defined in the literature as open or arthroscopic surgery in the surgical treatment of tibial spine fractures, none have been accepted as the gold standard technique to date.^[12] In a recent systematic review, no obvious advantages were reported regarding arthroscopic surgery when compared to open surgery.^[12] In the same study, no superiority was determined in the arthroscopic suture technique when compared to the arthroscopic screw technique.^[12] In another systematic review, the arthroscopic technique reduced some complications, such as postoperative pain and length of hospital stay.^[13] While deciding on the treatment technique of these fractures, the consideration of many factors, such as age, gender, body mass index (BMI), injury mechanism, and the experience of the surgeon, are important.

The aim of this study was to evaluate the clinical, functional, and radiographic results of the arthroscopic suture fixation technique, which was the preferred choice for the treatment of tibial spine fractures in a pediatric population, and identify the positive and negative aspects of this surgical technique.

MATERIALS AND METHODS

Approval for this study was received by the ethics committee of our institution, where the study was conducted. Retrospectively analyzed were 28 patients (17 males, 11 females; mean age 14.2; range 8–18 years) in the pediatric population who underwent arthroscopic suture fixation due to tibial spine fracture, between January 2013 and December 2017. Many patient parameters were evaluated, such as age, gender, BMI, injury mechanism, fracture classification, mean follow-up time, radiographic healing time, return to activity time, joint range of motion (ROM), Knee Injury, and Osteoarthritis

Outcome Score (KOOS) (6-, 12-, and 24-month values), instability examination (Lachman test), reoperation rate, and complications.

Included in the study were patients aged 8–18 years with type 2 (with >5 mm displacement), 3, or 4 isolated tibial spine fractures. Patients under 8 years, over 18 years, patients with pathology, such as cartilage damage, ligament rupture, meniscal tear, or other fracture within the knee joint, and without regular follow-up were excluded from the study.

All of the patients underwent standard knee anteroposterior and lateral radiography (Fig. 1a and b), and MRI images were administered (Fig. 2a and b) for preoperative diagnosis. Thus, tibial spine fracture was classified and the presence of additional intra-knee pathology was evaluated.

Surgical Procedure

All of the patients were operated on in the supine position and a pneumatic tourniquet was applied to control bleeding. Penetration into the knee joint was performed using standard anterolateral and anteromedial portals. Diagnostic arthroscopy was performed to evaluate whether there was additional pathology in the knee joint, in addition to the

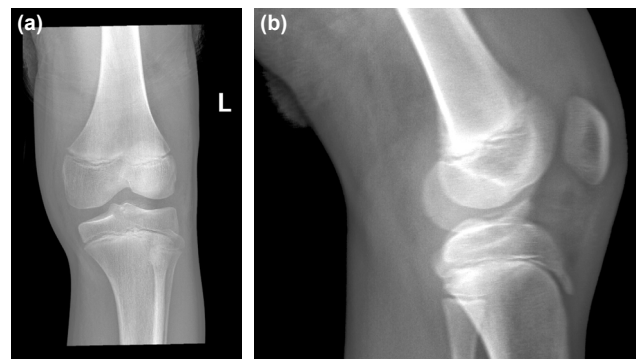


Figure 1. (a) Tibial spine fracture in standard anteroposterior radiograph of a 12-year-old boy with open physis. (b) Tibial spine fracture in standard lateral radiograph of a 12-year-old boy with open physis.

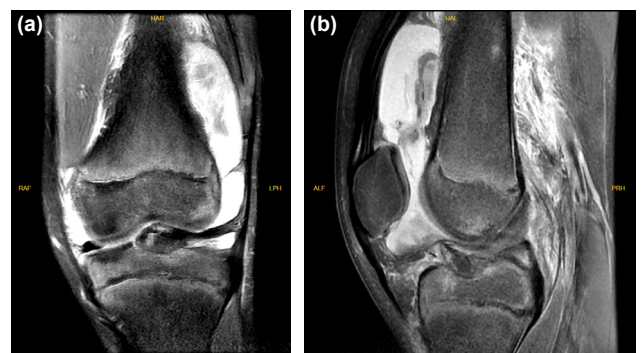


Figure 2. (a) The image of tibial spine fracture in coronal MRI T2 sequence of the same patient. (b) The image of tibial spine fracture in sagittal MRI T2 sequence of the same patient. Severe hemarthrosis is also observed in the suprapatellar pouch.

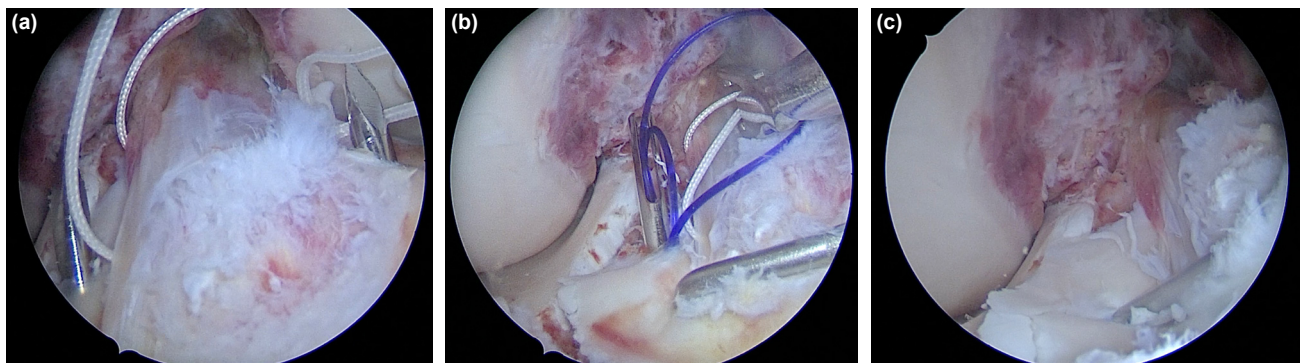


Figure 3. (a) Arthroscopic image demonstrating two sutures through the anterior and posterior parts of the anterior cruciate ligament. The fragment is temporarily fixed with two 2.4-mm guide pin. (b) Arthroscopic images demonstrating two sutures in the anterior and posterior part of the anterior cruciate ligament are transported to the tibial tunnels by a suture retriever. (c) Arthroscopic image demonstrating final fracture fixation with suture technique.

tibial spine fracture. After the fracture site was completely visualized, fracture reduction was confirmed using a probe. Meanwhile, if there was an interference-restricted structure, such as interposed meniscus, intermeniscal ligament, or soft tissue, it was removed using a 3.5-mm motorized shaver. After the anatomical reduction was confirmed, a No. 2 Ultrabraid suture (Smith and Nephew Inc., TN, USA) was passed through the posterior part of the ACL using a suture passer close to the tibial spine. Next, another No. 2 Ultrabraid suture was passed through the anterior part of the ACL (Fig. 3a). An ACL tibial guide was used to open a tunnel in the tibia by making a small anteromedial incision in the proximal tibia. The ACL tibial guide was placed in the lateral and medial sites of the fragment, respectively, and 2 tibial tunnels were opened using a 2.4-mm guide pin. A suture retriever was placed in these tunnels, and the lateral and medial suture limbs of the joint were carried out through the lateral and medial tunnels (Fig. 3b). After the reduction was checked for the last time, the sutures were knotted to the proper tension and tightened, so that the knot could not be released, with a post-fixation screw placed proximal tibia. After arthroscopic fracture fixation was completed (Fig. 3c), the intraoperative joint ROM was checked and the operation was concluded.

Rehabilitation

The knee joint was immobilized for approximately 4 weeks at 30° flexion with an angle-adjustable knee brace. Patients began passive exercises between weeks 4 and 6 postoperatively, and active exercises between weeks 6 and 8. After week 8, weight-bearing began to be correlated with radiographic fracture healing.

Statistical Analysis

All of the statistical analyses were performed using SPSS 15.0 (Chicago, IL, USA). The independent samples t-test was used to evaluate the parametric statistics and the Mann–Whitney U test was used to evaluate the nonparametric statistics. P<0.05 was accepted as statistically significant.

RESULTS

The demographic characteristics, injury mechanisms, and fracture types of the patients are presented in Table 1. The mean age of the patients was 14.2 years, and it was determined that the fractures were more frequently observed in the male population who were healthy according to their BMIs. Tibial spine fractures were mostly seen as a result of simple falls and hyperextension, and type 2 spine fractures occurred most constantly.

Data obtained during the follow-ups of patients with arthroscopic suture fixation, and a diagnosis of tibial spine frac-

Table 1. Demographic and injury characteristics of patients

Characteristic	Mean (min-max) or n (%)
Age at surgery, years	14.2 (8–18)
Sex	
Male	17 (61)
Female	11 (39)
Body mass index (kg/m ²)	
Underweight (<18.5)	3 (11)
Healthy weight (18.5–24.9)	20 (71)
Owerweight (25–29.9)	4 (14)
Obese (>30)	1 (4)
Injury mechanism	
Fall	9 (32)
Hyperextension	9 (32)
Twist	6 (22)
Collision	4 (14)
Modified Meyer and McKeever Classification	
Type 2	16 (57)
Type 3	10 (36)
Type 4	2 (7)

ture, are shown in Table 2. The patients had a mean follow-up time of 4.64 years. While the mean radiographic healing time was 2.17 months, the mean time to return activity was 7.56 months. No loss was observed in the joint ROM of the 26 patients (92%). Although approximately 5° extension loss was measured in 1 patient (4%), there was no functional limitation. In 1 patient (4%), a 30° flexion contracture occurred as a result of arthrofibrosis. This patient was reoperated on and arthroscopic synovium debridement and the release protocol were performed. According to the Lachman test performed on this patient, there was instability in the knee joint, but the patient did not have any clinical complaints and the fracture site was completely healed. It was seen that both patients were followed up without any problems.

In the patient follow-ups, the KOOS was used and the 6-, 12-, and 24-month KOOS scores were recorded after surgery, and are provided in Table 3. The mean 6-month score was calculated as 82.3, the mean 12-month score was 91.4, and the mean 24-month score was 95.7. When these scores were compared, a significant difference was observed between them (p=0.024).

DISCUSSION

In this study, the mid-term results of the arthroscopic suture fixation technique, which was the preferred choice for tibial spine fractures in a pediatric population, were evaluated. Sur-

gical treatment is recommended for type 2 fractures with >5 mm displacement, and for all type 3 and 4 fractures. In a study conducted by Edmonds et al.,^[14] patients with tibial spine fractures in a pediatric population were followed up conservatively by performing closed reduction followed by plaster. Although the risk of arthrofibrosis is low with this method, it has been reported that there is a lower rate of anatomic reduction and a severe joint laxity in long-term follow-up. For this reason, surgical treatment should be performed immediately in patients with an indication for surgery.

In recent years, knee arthrotomy, open reduction, and internal fixation were frequently preferred in the treatment of tibial spine fractures. However, the rate of arthroscopic visualization has increased in recent years with the development of arthroscopic equipment and orthopedic surgeons learning arthroscopic techniques.^[1] With arthroscopic visualization, a better view can be provided of the fracture site.^[15] In addition, when compared to the arthroscopic technique, knee arthrotomy, lower morbidity rate, earlier mobilization, and shorter hospital stay were detected in patients treated arthroscopically.^[16,17] Moreover, it is cosmetic because only 2 portals are used. However, since the arthroscopic suture technique has a learning curve, it should be applied by experienced surgeons who have mastered this technique.

Suture and screw fixation are the 2 most preferred methods in the arthroscopic technique.^[1] A strong internal fixation paves the way for a more aggressive rehabilitation. Thus, possible complications, such as joint stiffness, nonunion, malunion, or joint laxity are prevented.^[18] Arthroscopic screw fixation is preferred by many researchers because it is simple to apply and creates a strong compression on the fragment.^[19] However, the screws may cause weak fixation, especially in comminuted fractures.^[8] In the literature, some studies have shown that suture fixation is stronger than the screw biomechanically, provides more rigid fixation, and has a low frequency of failure.^[20,21] Clinically, less instability was detected in suture fixation patients in Lachman test examinations.^[22] In the present study, only 1 patient (4%) had instability in the Lachman test.

In the arthroscopic screw fixation technique, it has been reported that damage occurs in the posterior neurovascular structures and articular cartilage during screw placement.^[8] In a recent study, due to the need for implant removal, 44% secondary surgery was required in the screw fixation technique.^[16] Herein, secondary surgery was not required due to

Table 2. Follow-up outcomes in the postsurgical period

Outcome	Mean (min-max) or n (%)
Duration of follow-up, years	4.64 (2.4–7.3)
Time to radiographic healing, m	2.17 (1.1–2.8)
Time to return activity, m	7.56 (4.3–11.6)
Joint ROM, d, , n (%)	
Full (reached -5° to 130°)	26 (92)
Functional (did not reach -5° to 130° but no restriction)	1 (4)
Failure (severe ROM limitation)	1 (4)
Lachman, n (%)	
Stable	27 (96)
Unstable	1 (4)
Reoperation, n (%)	1 (4)

Table 3. The values of the IKDC questionnaire according to the follow-up period

	Mean (min-max) 6 th month	Mean (min-max) 12 th month	Mean (min-max) 24 th month	p-value
IKDC scores	82.3 (68–91)	91.4 (81–100)	95.7 (89–100)	0.024*

*Statistically significant. IKDC: International knee documentation committee.

implant removal in any patient. This is a distinct advantage of the arthroscopic suture technique over other methods.

Hunter and Willis^[23] compared two groups undergoing arthroscopic suture and screw fixation, and higher KOOS and better results were detected in the arthroscopic suture fixation. In the current study, KOOS was used for the functional scoring in the follow-up of the patients. As the follow-up time prolonged, better scores were seen and excellent results were obtained.

In a recent study, 27 patients with arthroscopic screw fixation were followed up and only 1 patient (4%) had a 10° flexion contracture.^[24] In another current study, 26 patients who had arthroscopic suture fixation were followed up and 2 patients (7%) had flexion contractures of 10° and 40°, respectively.^[25] In the present study, 26 patients (92%) had full ROM, while 1 patient (4%) had a 5° flexion contracture and no restriction was detected. Arthroscopic synovium debridement and release were performed in the patient (4%) due to 30° flexion contracture. There was a 10° residual flexion contracture. None of the patients in the current study had severe ROM limitation and satisfactory results were achieved in terms of joint ROM.

In a study by Callanan et al.,^[26] radiographic union times were compared, and the mean time was 3.2 months in the suture group and 5.3 months in the screw group; hence, a significant difference was found. In the present study, the mean radiographic healing time was determined as 2.17 months, which was a better result than that reported in the literature.

After surgical treatment of tibial spine fractures, the age of the patient was found to affect the results. In patients >18 years, worse functional outcomes were obtained than those <18 years.^[7] The reason for this was conditions such as postoperative stiffness, fracture displacement, the need for secondary surgery, and the fact that longer postoperative immobilization requirements increase with age.^[6] All of the patients included in this research were <18 years and excellent functional outcomes were obtained.

The arthroscopic suture fixation technique is more expensive than other methods. Special devices, such as multiple canulae, 2-mm Ultrabraid sutures, and a lasso-style suture passer are needed. The screw fixation technique can be seen as cheaper initially, but the total cost increases, since secondary surgery is often performed for implant removal.

One of the possible complications is growth disorder. In a recent study, 33 pediatric patients whose physes were open, were treated with ACL reconstruction by performing transphyseal drilling, and 24% of the patients showed growth disturbance in the operated limb.^[27] This risk was reduced in the current study using the all-epiphyseal technique. In the follow-up period of more than 4 years, none of the patients

experienced growth disturbance, but longer follow-up times were required.

There were some limitations in this study. First, this was a retrospective study and was based on the historical data of the patients. Second, the results of only one surgical technique were evaluated herein, and there was no cohort group used for comparison. Another limitation was that the KOOS scores used, especially for functional outcomes, may not have contained enough objectivity, because they were based on statements made by the patients. Moreover, the time from injury to surgery for each patient was not the same, and this difference may have affected the results. Finally, the mean follow-up time was insufficient and longer follow-up is needed for long-term outcomes and possible complications.

Conclusion

Consequently, tibial spine fractures in the pediatric population should be treated surgically to restore ACL length and facilitate early movement. Arthroscopic visualization has many advantages in treatment. Using suture as fixation material in the arthroscopic technique is more reliable in comminuted fractures and also eliminates the risk of secondary surgery for implant removal. Anatomical fracture reduction and aggressive rehabilitation in the early postoperative period are the most important criteria of success in treatment.

Ethics Committee Approval: This study was approved by the Yildirim Beyazit University Clinical Research Ethics Committee (Date: 13.05.2020, Decision No: 26379996/27).

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Conflict of Interest: None declared.

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ORJİNAL ÇALIŞMA - ÖZET

Pediyatrik popülasyondaki tibial eminensia kırıklarında artroskopik dikiş fiksasyon tekniğinin orta dönem sonuçları

Dr. Ceyhun Çağlar,¹ Dr. Hilal Yağar,² Dr. Fahri Emre,³ Mahmut Uğurlu⁴

¹Ankara Şehir Hastanesi, Ortopedi ve Travmatoloji Kliniği, Ankara

²Yozgat Şehir Hastanesi, Ortopedi ve Travmatoloji Kliniği, Yozgat

³Gülhane Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, Ankara

⁴Ankara Yıldırım Beyazıt Üniversitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, Ankara

AMAÇ: Tibial eminensia kırıkları, oluşum mekanizması açısından ACL rüptürüne benzeyen avülsiyon yaralanmalarıdır. İnsidansı çok fazla olmasa da, doğru tedavi edilmediği takdirde bazı komplikasyonlara ve diz ekleminde kalıcı hasarlara neden olabilmektedir. Bu çalışmadaki amacımız kliniğimizde pediyatrik popülasyondaki tibial eminensia kırıklarının tedavisinde uyguladığımız artroskopik dikiş tekniğinin orta dönem sonuçlarının değerlendirilmesidir.

GEREÇ VE YÖNTEM: Ocak 2013–Aralık 2017 tarihleri arasında bulunan tip 2 (>5 mm deplasman), 3 ve 4 tibial eminensia kırığı nedeniyle kliniğimizde artroskopik dikiş fiksasyon cerrahisi uygulanmış 28 hasta geriye dönük olarak incelendi. Hastalar; demografik özellikleri, yaralanma mekanizması, kırık sınıflaması, ortalama takip süresi, radyografik iyileşme süresi, aktiviteye dönüş süresi, instabilite muayenesi, eklem hareket açıklığı (EHA) ve KOOS parametreleri ile klinik ve fonksiyonel olarak değerlendirildi.

BULGULAR: Takip edilen hasta grubunun yaş ortalaması 14.2 olup, bu hastaların 17'si (%61) erkek cinsiyette ve 20'si (%71) vücut kitle indeksine göre sağlıklı popülasyondaydı. Modifiye Meyer and McKeever sınıflamasına göre en sık tip 2 tibial eminensia kırığı görüldü. Ortalama takip süresi 4.64 yıl olup, ortalama radyolojik iyileşme süresi 2.17 ay olarak hesaplandı. Yirmi yedi (%96) hasta EHA yönünden tamamen fonksiyoneldi. Bir hastaya artrofibrozis ve kısıtlı EHA nedeniyle ikincil cerrahi uygulandı. Ortalama altıncı ay KOOS 82.3, 12. ay KOOS 91.4 ve 24. ay KOOS 95.7 olarak ölçülmüş olup bu skorlar arasında anlamlı fark saptandı (p=0.024).

TARTIŞMA: Pediyatrik popülasyondaki tibial eminensia kırıklarının tedavisinde artroskopik dikiş tekniğinin sonuçları klinik ve fonksiyonel açıdan tatmin edicidir. Anatomik fiksasyon ve erken rehabilitasyon bu kırıkların tedavisindeki başarı oranını arttırmaktadır. Daha uzun süreli takipler bilizlere daha fazla bilgi verecektir.

Anahtar sözcükler: ACL; artroskopi; dikiş fiksasyon; KOOS; tibial eminensia.

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