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PEDIATRIC TIBIAL EMINENCE FRACTURES: ARTHROSCOPIC TREATMENT USING K-WIRE

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ABSTRACT

Background: **Fractures of the tibial intercondylar eminence are observed mostly in children and adolescents, often after minimal trauma. The purpose of this paper is to evaluate the use of K-wire fixation for the arthroscopic treatment of tibial eminence fractures in children.**

Patients and Methods: **From January 2002 through January 2009 ten patients were treated arthroscopically because of the intercondylar eminence fracture in a Department of pediatric surgery, University Hospital Split. Arthroscopically controlled reposition was done, and using mobile X-ray two crossed K-wires were introduced percutaneously from the proximal part of the tibia to the fractured intercondylar eminence. Subjective outcome was obtained using IKDC subjective questionnaire.**

Results: **Average hospitalization time was 11 days. Average duration of treatment was 12.5 weeks. Average follow-up was 42 months. Follow-up radiographs showed union in all cases. The mean IKDC subjective score was 96/100. Clinically, all patients exhibited a solid endpoint on the Lachman test. The global IKDC objective score was normal in eight knees and nearly normal in two knees.**

Conclusion: **Arthroscopic reduction and fixation by Kirschner wires or a small fragment screw is the best way for treatment intercondylar tibial eminence fractures, in the pediatric population, because is not crossing the epiphyseal plate.**

Key words: Arthroscopy; children; tibial eminence fracture; K-wire; International Knee Documentation Committee questionnaire (IKDC); intercondylar eminence

INTRODUCTION

Knee injuries are very common in the adolescence, and are generally the result of high – energy force across the joint. Fractures of the tibial intercondylar eminence are observed mostly in children and adolescents (1, 2). Intercondylar eminence fractures in skeletally immature patients usually result from injuries that would cause anterior cruciate ligament tears in skeletally mature patients. However, intercondylar eminence fractures can be caused by a spectrum of sporting activities and by motor vehicle accidents. Tibial eminence refers to the interarticular portion of the adjacent plateau of the tibia, and is the tibial attachment of the anterior cruciate ligament. Fracture of the intercondylar eminence is the reason of the knee instability. The integrity of the anterior cruciate ligament is compromised. Often, the fracture extends into the weight bearing portion of the articular surface of the medial tibial plateau. Reason to emphasize this fracture is that it is very serious injury. Patients with intercondylar eminence fractures pres-

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ent with knee pain and often the inability to bear weight. An effusion caused by the haemarthros is present. Although patients may keep the knee in a fixed position, the knee joint becomes unstable, and other knee structures may be damaged. The first descriptions of the intercondylar eminence fractures were filed in autopsy reports in 1875 (3). Pringle in 1907 first reported avulsion of the anterior tibial spine in children (4). Meyers and McKeever classified anterior eminence fractures into three types: type I, non-displaced; type II, partially displaced or hinged; and type III, completely displaced (5). This classification was modified by Zaricznyj and includes comminuted avulsion fractures (type IV) (6). No surgical treatment with immobilization in a long leg cast is suggested in cases of non-displaced tibial spine fracture (type I) (7, 8). Operative treatment is worthwhile in type II fractures, because they often include a substantial part of the medial tibial plateau. Intercondylar eminence fractures with complete avulsion of the fragment (type III) require surgical management to avoid anterior cruciate ligament laxity, pain and loss of motion (7, 8, 9). Recent literature papers report a lot of arthroscopic procedures with many advantages over arthrotomic techniques. The purpose of this study was to review pediatric patients having sustained fractures of the intercondylar eminence, and to indicate the value of arthroscopic treatment using K-wires, in the most simple and safe way.

PATIENTS AND METHODS

PATIENTS:

From January 2002 through January 2009, the case records were reviewed of ten patients (nine boys and one girl) treated arthroscopically because of the intercondylar eminence fracture in a Department of pediatric surgery, University Hospital Split. The age range was 12 to 17 years (mean 15 years). The fractures were classified using Meyers and McKeever's classification (5). During this 7-years study period, there were 21 children with intercondylar eminence fracture. Eleven patients with a no displaced fracture (type I) were excluded from the study, because they were all treated by immobilization in a plaster cast for 4 weeks. Immediately the patients started with passive physiotherapy, and after plaster removing they were switched to intensive physio-therapeutic training for about 3 months. All patients obtained complete pain relief without any limitation to their recreational activities. Other ten patients, with displaced fractures, were operated as soon as possible. The right knee was involved in 6 cases and the left in 4. The patient characteristics are outlined in Table 1. Injury mechanisms were sport activities, motorbike or bicycle riding. After clinical examination, routine radiography (anteroposterior and lateral X–ray) (Fig. 1) of the knees showed the fracture, but the displacement and the comminution of the avulsed fragment was precised pre operatively by MSCT-Scan. According to Meyers and Mc Keever's (5) classification modified by Zaricznyj (6), there were five fractures type II, four type III fractures and one type IV fracture. Associated injuries are described in Table 1. If patella ballotement was presented during clinical examination, punction of the knee was diagnostically and disburden procedure. Usually we found about 100 cm^3 of blood (range 60–140 cm^3).

SURGERY:

The patient is in the supine position with the knee in 90º of flexion. A pneumatic tourniquet is used. The arthroscopic view is obtained from an anterolateral portal. After hematoma debridement and exposure of the fracture, using a shaver through an anteromedial portal, interposed tissue and transverse ligament is removed so that the avulsed bone fragment can be easily reduced. No special measurements are taken to prepare the fracture bed. In cases with interposition, the ligament is shifted aside with a probe introduced through the superior anteromedial portal to make reduction possible. Anterior and posterior cruciate ligaments are inspected. Because of the high proportion of the involvement of the intermeniscal ligament in the fracture gap and the entrapment of the meniscus, the anterior part of the fracture should always be visualized. This presents a considerable technical problem, because of the infrapatellar fat pad that obscures the anterior part of the joint. Another technical problem is the shift of the intermeniscal ligament and removal of the entrapped meniscus from the fracture gap with one or more hooks to achieve a reduction of the fragment. After the fragment is reduced, temporary fixation of fracture is relatively simple. Through an anterolateral or anteromedial approach, we do reposition of fractured fragments and reduction of the fracture with the arthroscopic hook. The choice for the lateral or medial approach depends on the fracture pattern. Using mobile X-ray two crossed 1.8 mm K-wires are introduced percutaneously from the proximal part of the tibia, to the fractured intercondylar eminence. K-wire is introduced from medial and inferior to the tibial tuberosity. Using mobile X-ray a first 1.8 mm K-wire is drilled (in 70º position) from the

TABLE 1

Patient characteristics

Patient	Gender	Age	Side	Accident mechanism	Classification	Associated injuries
001	Male	17	Right	Voleyball fall down	Type II	–
002	Male	15	Left	Handball fall down	Type III	Ruptura ligamentum cruciatum anterior
003	Male	14	Left	Bicycle fall off	Type IV	Fractura condyli lateralis tibiae
004	Male	15	Left	Football fall down	Type III	Ruptura ligamentum cruciatum anterior
005	Male	17	Right	Jump reception	Type II	–
006	Male	17	Right	Football fall down	Type III	Ruptura menisci lateralis
007	Male	14	Right	Lead tube squash	Type II	Fractura condyli lateralis femoris
008	Male	14	Left	Scooter fall off	Type III	Epiphyseolisis partis proximalis tibiae
009	Female	15	Right	Voleyball fall down	Type II	–
010	Male	12	Right	Football fall down	Type II	–

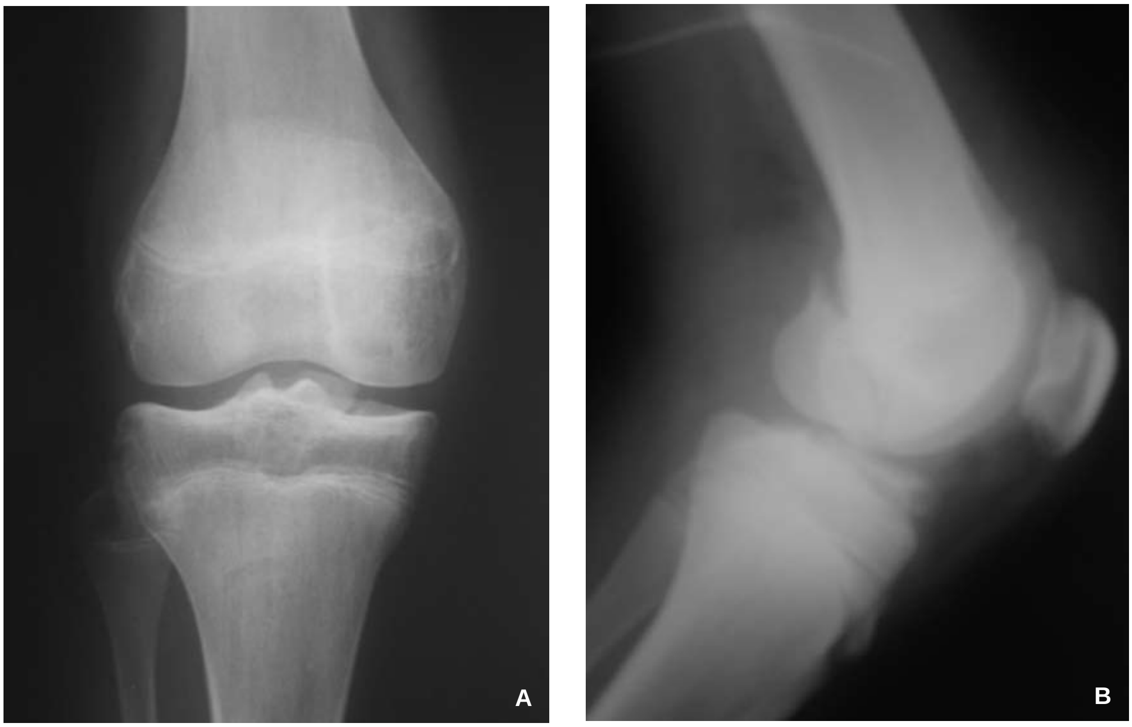

Fig. 1. Fracture of intercondylar eminence, type II. A) Anteroposterior projection. B) Lateral projection.

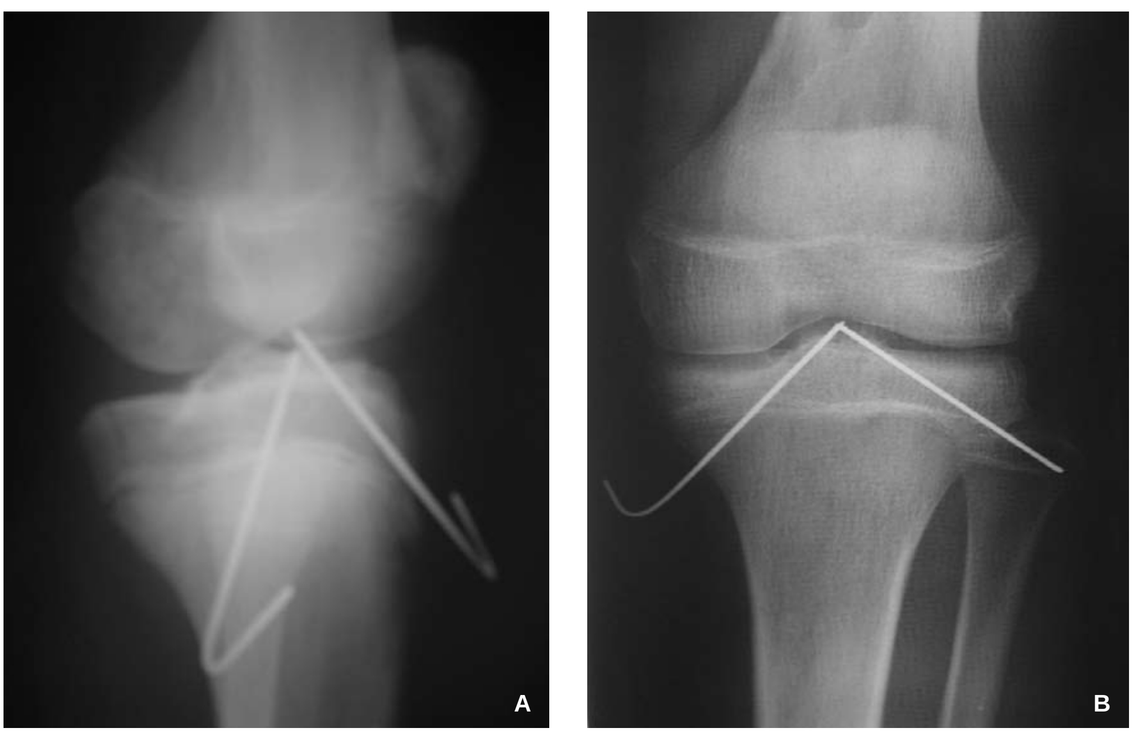

Fig. 2. Fracture of the intercondylar eminence after reduction and placed crossed K-wires. A) Lateral projection. B) Anteroposterior projection.

proximal tibia into the reduced fragment, just anterior to the ACL insertion. When introducing the K-wire, it is very important to hold arthroscopic hook on fracture place, to resist the fracture from dislocation. After we ensure the K-wire is well placed, and ACL is in correct position under good tension, another 1.8 mm K-wire is drilled from the opposite side to complete the fixation (Fig. 2). The knee is placed in extension and an anterior impingement is checked. The tips of the K-wires are controlled arthroscopically. Redon drainage is applied. Tutor plaster is applied immediately after surgical procedure, and a week after operation semi rigid immobilization is set. Semirigid immobilization is used mostly because of our good experiences in keeping thigh muscles in a good condition with this type of immobilization. Totally, immobilization is set for four weeks. Rehabilitation is started on the first day after surgery with patellar mobilization and quadriceps isometric strengthening exercises. Redon drainage is removed on the first postoperative day. After four weeks standard X – ray is performed, and physiotherapy program is started for ten weeks. Six weeks after arthroscopy K wires are pulled out.

METHODS:

Our results are based on clinical evaluations during a mean follow-up of 42 months (range 9–78 months). Subjective outcome was obtained using the IKDC subjective questionnaire, looking at knee function, symptoms and activity levels. The patients were clinically evaluated using the International Knee Documentation Committee (IKDC) (10) objective form which noted swelling, range of knee movement, Lachman test, sagital and frontal plane laxity compared to the normal opposite knee. The lowest grade was used to define the final result. Radiological investigation included antero posterior and lateral X-rays to evaluate the fracture union.

RESULTS

Six weeks after arthroscopy K wires were pulled out. Average hospitalization time was 11 days (range, 7 to 21). Average time from injury to surgery was 5.5 days (range, 1 to 12). This relatively long time from injury to surgery is because some patients did not immediately come to our Pediatric surgery emergency department, and we also noticed that in patients who were operated few days later after the injury was significantly less bleeding in the knee. Average duration of treatment was 12.5 weeks (range, 7 to 37). Average follow-up was 42 months (range, 9 to 78). Follow-up radiographs showed union in all cases. At follow-up examination, one was satisfied and nine patients were very satisfied with their knee. They had all returned to their pre injury activities at the same level without any complaint about instability. The mean IKDC subjective score was 96 out of 100 (range 85–100) (Table 2). Clinically, all patients exhibited a solid endpoint on the Lachman test. The global IKDC objective score was normal (A) in eight knees and nearly normal (B) in two knees: two knees presented a comparative 5º extension lack, there were no lack of flexion, and no effusion. The details are outlined in Table 2. We never reported cases of ischemic damage due to the ACL insertion. X- rays showed an anatomic reduction and union of the avulsed fragment. All patients obtained complete pain relief without any limitation to their recreational activities.

DISCUSSION

Fracture of the intercondylar eminence is of great importance because it is attachment of an anterior and posterior cruciate ligament. If there is displacement of fractured fragments during clinical exam the knee joint is found loose. Fracture of the posterior intercondylar eminence is a very rare fracture in children and according to Roberts and Lovell ratio, fracture of the anterior eminence to the fracture of the posterior eminence is 10:1. Surgical treatment of displaced intercondylar eminence fractures is essential to prevent non-union or malunion, which can cause knee pain, instability or loss of knee extension (11). Open surgery allows anatomic fracture reduction and secure fixation for early mobilization, but cause some morbidity (12–14). McLennan (15), in 1982, first advocated the advantages of arthroscopic treatment for tibial eminence fractures in terms of minimal morbidity and treatment of associated lesions. It allows haemarthrosis washed, fracture inspection and removal of interposed tissue under the fragment. Successful arthroscopic reduction and fixation techniques have been described in recent literature (16–22). The limits of the arthroscopic fixation techniques are related to technical difficulty and unstable fixation. Most authors agree on the conservative

TABLE 2

Subjective and objective evaluation at follow-up

		Subjective evaluation at follow-up			Objective evaluation at follow-up
Patient	Follow-up	Satisfaction	Activity level	IKDC subjective score	IKDC GLOBAL
1	78	VS	Regular	100	A
2	62	VS	Regular	97	A
3	60	VS	Regular	98	A
4	58	VS	Regular	100	A
5	46	VS	Regular	92	B
6	45	VS	Regular	100	A
7	31	S	Regular	85	B
8	20	VS	Regular	96	A
9	11	VS	Regular	100	A
10	9	VS	Regular	92	A
Average	42	VS	Regular	96	A

Legend: VS – very satisfied, S – Satisfied
A – normal; B – nearly normal; C – abnormal; D – severely abnormal

treatment of type I fracture of the intercondylar eminence (22–24). Operative treatment is worthwhile in type II fractures, because they often include a substantial part of the medial tibial plateau. Reduction of the completely dislocated fragment (the type III fracture) is more technically demanding than type II fracture. It is therefore our opinion to consider these two groups in a separate way. Open reduction and internal fixation is often performed by suturing the fragment with absorbable sutures to the proximal tibia (14, 25).

Reynders at al. analyzed a series of 26 cases of displaced fractures of the intercondylar eminence of the tibia treated with an arthroscopically placed, intrafocal screw with spiked washer. The patients were reviewed after a minimum follow-up of 24 months and a maximum of 8 years. The authors found the intrafocal screw fixation for displaced fracture of the intercondylar eminence to be a reliable and safe technique, although complete restoration of the anteroposterior knee stability was seldom seen (8).

Senkovič et al. reported series of thirty-two patients treated arthroscopically for type II, III, and IV fractures of the intercondylar eminence of the tibia. The fragments were reduced and fixed with a cannulated screw or cannulated screw and washer. The intermeniscal ligament was involved in the fracture in 29 cases, and the anterior part of the medial meniscus was involved in 3 cases, requiring a temporary shift before reduction of the fragment. All patients began continuous passive and active motion of the involved knee and were mobilized on crutches the day after the procedure. They found good therapeutic results at follow-up. Average value for KT-1000 testing was 1.1 mm; flexion deficit was 1.2°; extension deficit, 0.6°; and Lysholm score, 98.8. The average treatment duration was 12 weeks. There was one case of aseptic synovitis and no other complications. In our series flexion deficit was 1.25°, no extension deficit was found (26).

Berg (25) reported two arthroscopic suture failures of comminuted intercondylar eminence fractures caused by unstable fixation. Meyers and McKeever warned of the potential poor results in treating intercondylar tibial eminence fractures in adults (5). They had 45% poor results and attributed this to associated ligamentous injuries, which they suggested should be repaired. Smith (27) noted some evidence of ACL laxity in all 15 patients with fractures of the intercondylar eminence of the tibia that he reviewed. Gronkvist (28) reported ACL insufficiency in 47% of patients treated for anterior tibial spine fractures. The authors suggested that the ACL stretches before failure of the bone occurs at its tibial attachment. We had good results on anterior tibial translation without complaints of instability, probably due to fragment compression and ACL tensioning by the wire. Baxter and Wiley (11), reviewed 45 patients 3–10 years after tibial spine fracture. In their study, all patients had a measurable loss of extension of the injured knee (range 4–15). Fifty percent had a positive anterior drawer test without subjective feeling of knee instability. They did not find any correlation between tibial spine reduction and either laxity or loss of full extension of the knee. They postulated that enlargement of the tibial spine after injury is due to an increase in local blood supply during the healing stage.

Lukas et al. find that outcome of surgery is not dependent on the fixation material used. In their series fixation was carried out with a Kirschner's wire, cannulated screw, wire loop or absorbable suture. Theirs technique and results are very similar to ours, they found restricted motion in three patients, and no positive anterior drawer or Lachman's tests were recorded. In our series we found only extension deficit in two patients, no flexion deficit was found. We agree that arthroscopy is considered the most suitable technique for the treatment of fractures of the intercondylar eminence of the tibia, because it is minimally invasive and provides a good view of the operative field (29).

Delcogliano et al. reported surgical treatment of the intercondylar eminence fractures with absorbable or nonabsorbable suture fixation of 15 cases of type II and III tibial intercondylar eminence fractures. They reported very good results, similar to ours. According to the IKDC scoring system, recovery of the 13 patients not undergoing additional intervention was graded as normal (A) or near normal (B). In 14 patients, anterior laxity was inferior to 5 mm at the KT-1000 arthrometer evaluation (7).

Bonin et al. reported technique for arthroscopic fixation of tibial intercondylar eminence avulsion fractures using folded surgical pin. This technique allows reduction and fixation of the bone fragment, similar to ours. The only difference to our technique is that we are using two crossed K-wires to stabilize fracture. They use one K-wire, which is drilled through the guide from the proximal tibia into the reduced fragment. It is bent on its end into the joint with a strong needle case. The K-wire is then pulled back until good fragment compression to the tibia appears with the wire starting unbending. This arthroscopic fixation allows elastic compression fragment stabilization that authorizes early weight bearing and rehabilitation programs (30). The global IKDC objective score was normal (A) in two knees and nearly normal (B) in three knees: two knees presented a comparative 5° extension lack; one knee had a 4 mm side-to-side anterior tibial translation difference. IKDC subjective score was 90 (30).

Hunter et al. compared suturing and screw fixation, and reported that displaced tibial eminence fractures could be successfully treated in both younger and older patients using arthroscopic suture or screw fixation, with most patients returning to their previous activity levels. We find this technique also good, with excellent results, similar to ours. They concluded that the interposed intermeniscal ligament must be retracted to allow for anatomic fracture reduction, which we agree, and have described in previous part (31).

The biomechanical stability of knee is very important. Mahar et al. made very interesting study, in which they compared the biomechanical stability of tibial eminence avulsion fractures using suture, resorbable screw, resorbable nail, and metal screw techniques. They found no significant mechanical differences across groups. The variability in performance was much greater for both the suture and resorbable screw repairs. Both sutures and resorbable screw constructs resulted in a deformation that was 1 mm greater than that of the resorbable nails or a metal screw (32). Our arthroscopic technique provides a rigid internal fixation and allows early postoperative rehabilitation.

Our study, however, was carried out on a smaler series of patients, with a longer term average follow-up. We believe that this arthroscopic procedure is an excellent alternative to other previously described arthroscopic methods, considering all their possible complications. The procedure we performed eliminated complications relating to comminution of the fragment and maintained all the advantages offered by arthroscopic techniques. This arthroscopic technique provides a rigid internal fixation and allows early postoperative rehabilitation.

Nowadays newer techniques are presented. Hirchmann et al. reported a novel physeal sparing arthroscopic technique for anatomic suture refixation of tibial eminence fractures and assess the mid-term results of six consecutive patients. No loss of reduction or grossly physeal disturbance was observed. The reported surgical technique showed excellent to good clinical and radiological results and may be a physeal sparing alternative to previously described procedures. The main conceptual advantage of their operative technique described is that a stable and safe reduction and fixation is achieved arthroscopically with non-absorbable sutures and without the use of any intraarticular metal hardware (33).

Possible disadvantages of the arthroscopic fixation methods are: loss of reduction, residual anterior laxity, loss of extension, damage of the physis and subjectively disturbing fixation devices. (33) In addition, it is important, particularly in children, not to iatrogenically damage the open growth plate with the surgical procedure (33, 34). This is in contrast to several previously reported techniques that drill tunnels into the tibia or femur possibly leading to damage of the physis such as anterior growth arrest or hyperextension deformity (4, 14, 35, 36). With our described technique there were no evidence of damage of the tibial physis.

Park et al. used arthroscopy to evaluate the outcomes after surgery to repair intercondylar eminence fractures. They find in patients who have knee complaints, sucha as catching and loss of knee extension, a secoond-look arthroscopy is useful for identifying and correcting the problem (37).

Arthroscopic reduction and fixation by Kirschner wires, in our opinion, is the best way for treatment intercondylar tibial eminence fractures, in the pediatric population, because it avoids damage of epiphyseal plate. Our results on knee extension appear better probably because of stable fixation allowing a safer rehabilitation that could be started the day after surgery. The minimal size of the fixation device probably avoids damage to the open physes, so it could be used in the pediatric population. Our technique with surgical K-wire fixation has several advantages: it is a relatively simple reliable arthroscopic technique; the fixation is stable and can be completed with other folded K-wire if necessary; the fixation pin is easily removed by traction, which is an advantage in the pediatric population. All fractures in our series healed with excellent results, meaning that fixation of a solitary fragment with a K-wire is stable enough to allow immediate full weight bearing and full range of motion exercises after immobilization for 4 weeks. At follow up in 10 patients with solitary injury of the tibial eminence, the clinical and subjective result was normal in 8 (80%) and nearly normal in 2 (20%) patient.

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