Arthroscopic Fixation of Intercondylar Eminence Fractures Using a 4-Portal Technique

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Purpose: We report an easy-to-use 4-portal technique for arthroscopic treatment of intercondylar eminence fractures and compare results of 2 groups of cases, adolescents and adults, and 2 types of internal fixation, sutures and screws. **Type of Study:** Surgical technique and retrospective study. **Methods:** The study was carried on 2 groups of patients, adolescents and adults, with intercondylar eminence fractures who were treated arthroscopically. For internal fixation, sutures were used in 8 adolescents and screws were used in 13 adults. In the technique we describe, anteromedial superior and inferior, and anterolateral superior and inferior portals were used. **Results:** The average follow-up period for the adolescents was 27.3 months (range, 11 to 57 months), and for the adults was 19.6 months (range, 7 to 71 months). We did not encounter any cases of nonunion. There were only 3 complications, 1 of arthrofibrosis resulting from a delay of rehabilitation due to a vascular compromise and 2 cases of tenderness over the screw that responded well to its removal. Union occurred earlier in adolescents, but rehabilitation was easier in adults. **Conclusions:** Beside satisfactory results obtained by arthroscopic treatment of intercondylar eminence fractures, arthroscopy also provides the possibility to determine and treat associated pathologies. With the experience we gained, the procedure with the 4-portal technique in treating these fractures became much easier as a routine approach. **Key Words:** Intercondylar eminence—Fracture—Arthroscopy.

Fractures of the tibial eminence are generally observed in children and adolescents. In children, the epiphyseal plate that the anterior cruciate ligament (ACL) is attached to offers less resistance than the ACL substance to tractional forces that can lead to these fractures.[1,2] Similar loads cause rupture of the ligament in adults, and thus intercondylar eminence fractures are rarer among this group. The overall results of treatment are not as satisfactory in adults compared with children and adolescents. Sequelae following conservative management and surgical treatment of these fractures with inappropriate techniques may include limitation in range of motion, anterior knee pain, loss of extension due to mechanical block in the intercondylar region, and residual ACL laxity.[3-6]

Intercondylar eminence fractures of the tibia were first described by Poncet in 1875.[7] Meyers and McKeever[2] classified these fractures according to the severity of displacement: type I fractures have minimal or no displacement of the fragment from its place on the tibia, type II fractures have the anterior one third to one half of the tibial eminence avulsed and hinged, and type III fractures involve complete separation. Appropriate treatment should provide anatomic reduction of the fragment. Zaricznyj[6] further divided type III fractures into classes A and B, where type IIIA describes the pathology when the fragment with complete separation is displaced minimally, and type IIIB when the fragment is twisted or fragmented resulting in rotational malalignment. These types of fractures may be impossible to reduce because soft tissue or the

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meniscus prevents proper seating of the fragment.[2,6,8,9] Anatomic reduction and stable internal fixation are required for the restoration of normal knee biomechanics.

The first applications of arthroscopy to intra-articular fractures were reported as limited series or technical notes in the early 1990s.[9-15] All of these studies place great emphasis on the advantages of the arthroscopic techniques. Despite the successful results of the arthroscopic procedure, it is technically demanding. Techniques that allow reduction but with inappropriate and unreliable fixation carry the risk of the loss of reduction and make early rehabilitation impossible. Fixation may be achieved with the help of various implants such as sutures,[8,10-12] Kirschner wires,[2,10] and screws.[9,11,16]

Following on the studies mentioned above, we have started to use arthroscopic techniques in the fixation of intercondylar eminence fractures in adolescents and adults.[11] We began to use some technical alternatives as our experience in arthroscopy progressed. The aim of this study is to describe the technical advantages in the hope that it will contribute to this technique becoming a routine arthroscopic procedure.

METHODS

The study included 21 cases of intercondylar eminence fracture, divided into 2 groups, adolescents and adults, treated arthroscopically between 1992 and 1998 in the Department of Orthopaedics and Traumatology, Ankara University Ibn-I Sina Hospital. All patients had displaced fractures with well-established indications for surgical intervention. Conservatively treated, nondisplaced fractures were not included in this study.

The adolescent group consisted of 8 patients, 5 girls and 3 boys, and the adult group included 13 patients, 5 women and 8 men. The average age in the adolescent group was 11.2 years (range, 9 to 14 years) and in the adult group was 27.4 years (range, 18 to 39 years). The average of all patients was 19.3 years (range, 9 to 39 years). The right knee was involved in 13 patients and the left knee in 8. Mechanisms of injury are presented in Table 1.

TABLE 1. *Mechanisms of Injury*

Mechanism	No. of Cases
Falling	3
Sports-related activity	9
Traffic accident (2 cases falling off bike)	4
Unknown	3

There were 16 patients who underwent surgery in the first week following injury, all of whom had hemarthrosis and loss of motion of the knee. The other 5 patients came to the hospital 1 week or more after their injury. They had no signs of union on their routine radiographs, their physical examinations revealed instability, and 3 of them also had loss of motion.

Diagnosis was confirmed by the clinical findings and radiographic assessment. Magnetic resonance imaging (MRI) was performed in 15 patients; 6 had type II fractures according to the Meyers and McKeever classification,[2] and 15 had type III fractures. Three of the patients had an associated medial collateral ligament lesion, and 5 had lateral femoral condylar cartilage contusion. All arthroscopic fixation procedures were carried out by the same surgeon (M.S.B.). In 8 of the adolescents, fragments were fixed with multiple sutures, whereas in 13 of the adults, fixation was performed with screws.

Technique

Two different techniques, having common points, were applied to the 2 different groups. In the supine position, tourniquets were applied and knees were positioned in 90° of flexion. In our technique, 4 portals were used: anterolateral superior, anterolateral inferior, anteromedial superior, and anteromedial inferior (Fig 1). At the beginning of the procedure, standard anterolateral superior and anteromedial inferior portals were used to drain the hematoma, irrigate the joint, and examine any accompanying injuries. Necrotic tissue was curetted and fracture surfaces and bed were debrided of interposed soft tissue. In 5 cases, a motorized shaver was required for the debridement of the fibrous tissue covering the fracture surface.

After visualization of the fragment, its position and anatomic relations in the intercondylar notch were re-examined. Nine cases required debridement of tissues obstructing reduction (Fig 2). The goal was to obtain an anatomic reduction. The 2 other portals were used because of the position of the fragment. Entrance inclinations through these portals were determined to provide ease in the maintenance of reduction and fixation of the fragment.

Meanwhile, via the anteromedial inferior portal, a probe or ACL tibial guide (Smith & Nephew Endoscopy, Andover, MA) were used to push the fragment pieces into the original location. The position where

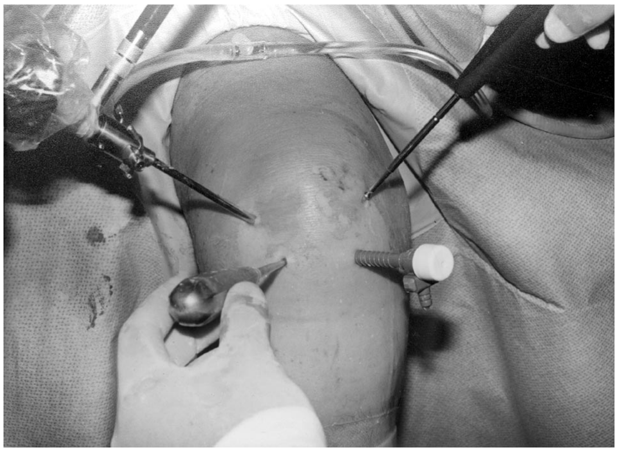

FIGURE 1. Our technique: with the arthroscope in the anterolateral superior portal, reduction is maintained by a curette via anterolateral inferior portal and the fracture is fixated by a screw via anteromedial superior portal. The location of the anteromedial inferior portal for additional procedures is shown.

anatomic reduction could be obtained was to be determined. The anteromedial superior and anterolateral inferior portals were located so as to provide ease in continuation of reduction and in screw insertion. While the arthroscope was in the anterolateral superior portal, fragments were held steady with the help of a probe or a curette via the anteromedial inferior portal. A K-wire was used for preliminary fixation of the fracture via the anteromedial superior portal (Fig 3).

Because of the open physes in adolescents, sutures were used after confirming the security of the fixation, as described by Berg[10] and Matthews and Geissler.[14] The anterior horn of the lateral meniscus and other fibrotic tissues, being obstacles to reduction, were removed to the side under direct visualization. As also recommended by Matthews and Geissler, we tried not to harm the intermeniscal ligament. Sutures were passed via the anteromedial inferior portal. Although we started the procedure with the standard portals in adolescents, greater ease could be obtained with the addition of a medial portal for suture fixation of the ACL. No. 0 or 1 PDS or other nonabsorbable sutures were used with the help of an ACL Stitcher (Acufex Microsurgical, Mansfield MA) or other similar suture punch instruments. They were passed from posterior to anterior and as many as needed were used (usually 4 or 5) according to the shape and size of the base of ACL (Figs 4 and 5).

After the intra-articular procedure, an incision 3 to 4 cm long was made at the medial and inferior side of to the tibial tuberosity. Under arthroscopic visualization of the fracture base, 2 K-wires were passed from the proximal tibia to the fracture bed with the help of an ACL endoscopic drill guide (Smith & Nephew Endoscopy). At least 1 cm of space should exist between the 2 wires and the wires should exit immediately anterior to the insertion point of the ACL or the fracture bed. Through the tunnels made by the wires, a suture retriever (Smith & Nephew Endoscopy) was passed and sutures were taken out of the joint. A 35-

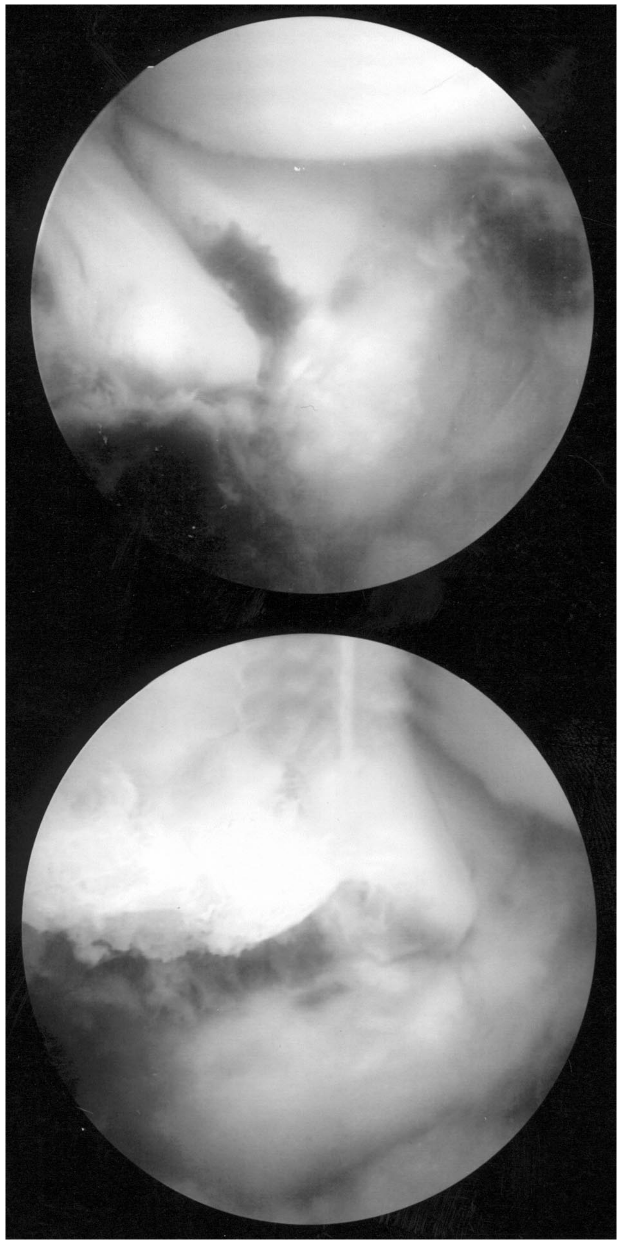

FIGURE 2. Interposition of the anterior horn of the meniscus to the fracture line in an adult case.

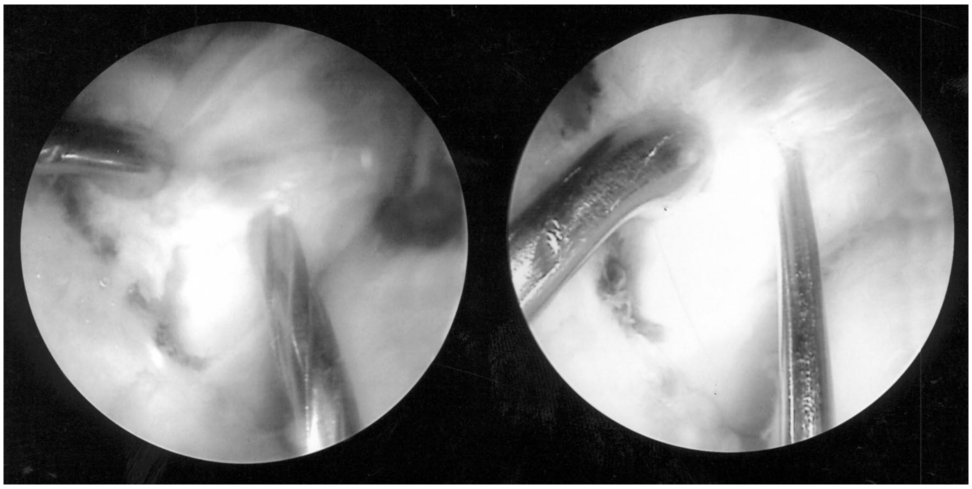

Figure 3. An adolescent case: the fragment is held in place with the help of a curette, preliminary fixation is done by a K-wire via the anteromedial superior portal, and is drilled with a cannulated drill.

to 40-mm long mini AO/ASIF cancellous screw was placed in the proximal tibia (Fig 6). Probing the tightness of the ACL through the arthroscope, the knee was extended and the sutures were tied around the screw neck. After confirming the fracture stability within the whole range of motion, the procedure was finished.

Figure 4. Preoperative view of a type III eminentia fracture in an adolescent.

A different technique for more stable fixation was required for the adult patients. After performing reduction as described above, the fragment was fixed with a K-wire through the anteromedial superior portal. Reduction and stability of the fragment were checked in the whole range of motion of the knee and also radiologically. The fragment was drilled by a cannulated drill via the anteromedial superior portal over the K-wire (Fig 3). A 4-mm cannulated cancellous screw (Smith & Nephew Endoscopy) was inserted (Figs 1 and 7). Then the arthroscope entered through the anteromedial inferior or anterolateral inferior portal and a second K-wire brought through the anterolateral superior portal was used before application of the second screw. Care was taken during application of the second screw not to disturb the compressive effect of the first screw (Figs 8 and 9). The procedure was complete when the stability of fixation was confirmed in the range of motion.

On the first postoperative day, continuous passive motion was started within the range of 0° to 90° as much as the patient tolerated. All patients were allowed 90° of flexion with long hinged leg braces for the first 3 weeks, and thereafter with adjustable range of motion lock for the next 3 weeks. After the third week, the degree of flexion could be increased to more than 90° depending on the type of injury and reliability of fixation. The brace was locked in extension during the whole rehabilitation period. For the adolescent group at 4 to 6 weeks and for the adult group at 6 to 8 weeks, non–weight-bearing mobilization was allowed. During mobilization, 2 crutches were used by all patients. After this period,

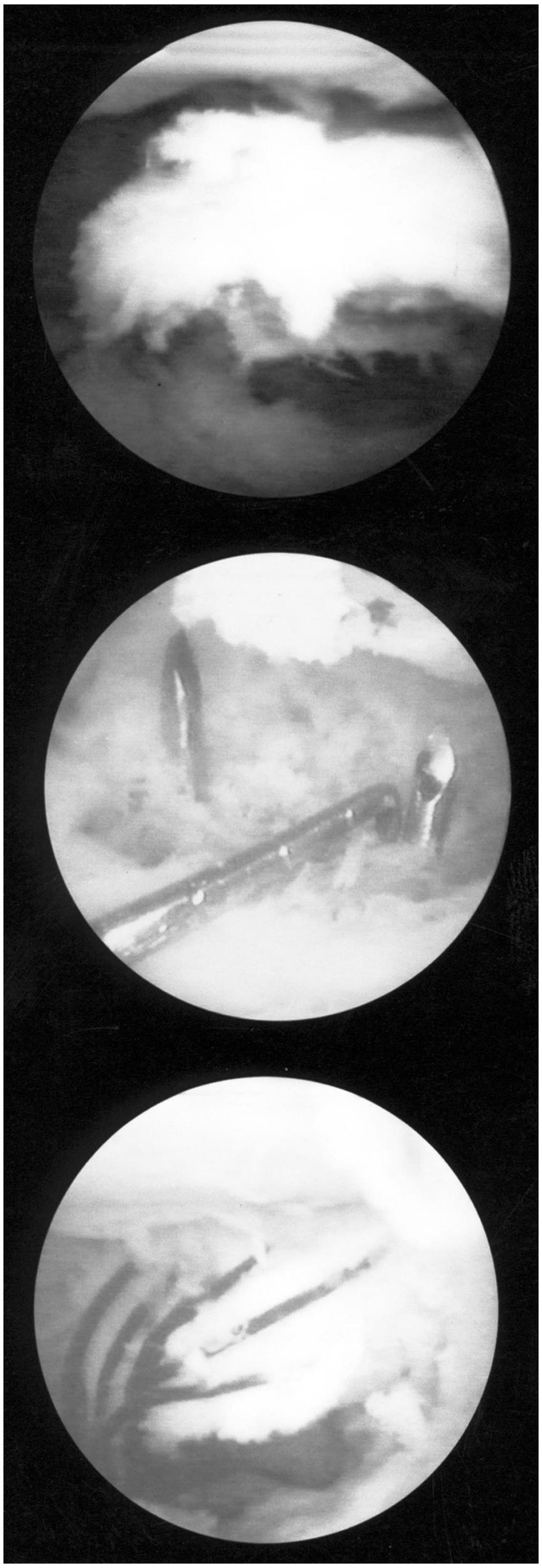

Figure 5. A case of type III fracture: arthroscopic view of the fracture with 2 K-wires located at the fracture bed. The fragment is fixated by sutures with the anterior cruciate ligament.

Figure 6. The case shown on Fig 4: fixation on the tibia is seen after the union is complete.

full weight bearing without the use of a brace was encouraged. Exercises for strengthening the musculature around the knee were performed throughout the postoperative period. Quadriceps sets and hamstring-tightening exercises were initiated postoper-

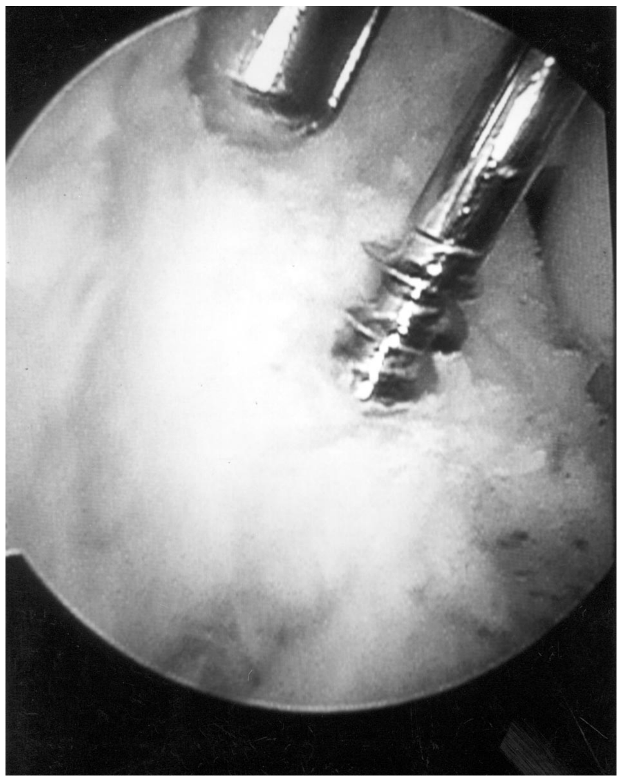

Figure 7. Application of a 4-mm cannulated cancellous screw for fracture fixation.

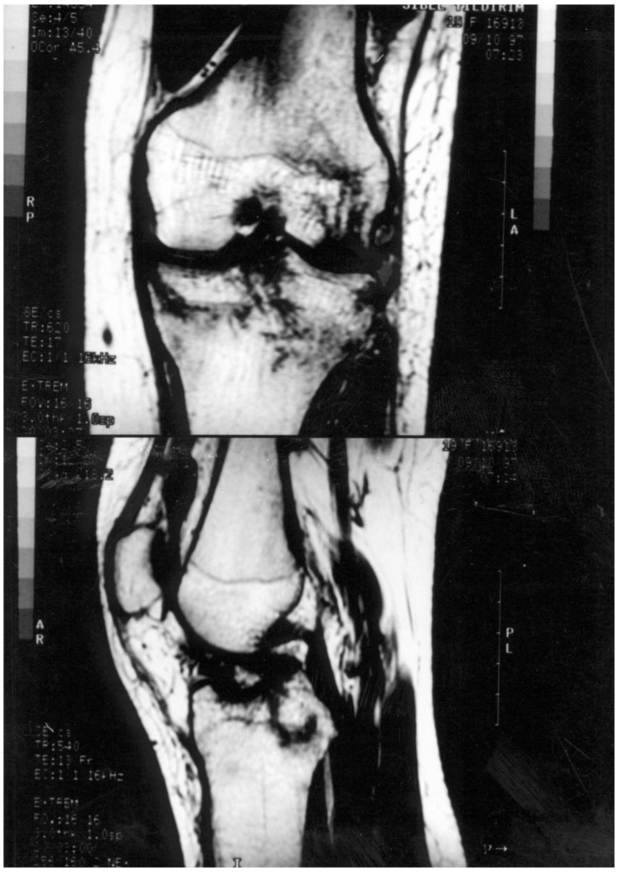

FIGURE 8. A case of a 19-year-old adolescent: preoperative MRI showing type III eminentia fracture associated with fracture of the tibia plateau.

atively. Therapeutic exercises, including heel slides, quadriceps sets, patellar mobilization, non–weight-bearing gastrocnemius/soleus strengthening, and straight leg raising in all planes with brace in full extension until quadriceps strength was sufficient to prevent extension lag, were initiated immediately as much as the patient could tolerate. The phase I rehabilitation period included the first 4 to 6 weeks following the operation, when immediate pain and inflammation control was necessary. During this period, the aim was full extension. For the first 4 to 6 weeks, the brace was locked in extension while sleeping and then unlocked for ambulation. During this time, progressive muscular strengthening exercises were performed and, as weight bearing was allowed, these exercises were increased in all directions. The workout was supported with proprioceptive exercises. Sports activity was allowed after 6 months.

RESULTS

The average follow-up time for the adolescents were 27.3 months (range, 11 to 57 months), and for the adults was 19.6 months (range, 7 to 71 months). All follow-up examinations were carried out by the same team. Clinically, the patients did not have any complaint of pain. Five patients developed hydrarthrosis, which lasted until the removal of the screws, but they were all less than 40 mL in amount. Regarding the average range of motion, there was an average 13° loss of flexion (range, 0° to 40°), and an average 3° loss of extension (range, 0° to 10°) (Table 2).

Radiologic controls revealed callus formation as early as 4 weeks and as late as 11 weeks, with an average of 7.1 weeks. There was no nonunion found in any patient, and unions occurred as early as 6 weeks and as late as 15 weeks, with an average of 8.3 weeks.

The screws in 11 patients were removed by a second arthroscopic procedure after complete union was achieved. Adhesions at the fracture site were debrided in 4 cases. Arthroscopic confirmation of the union was made in all of these patients (Figs 10-12).

We had 1 early and 2 late complications. The 1 early complication occurred in a patient with a type III fracture who had not received any treatment for 4 weeks before administration to our clinic. He presented with complaints of instability and loss of motion. His surgery lasted 1 hour and 50 minutes and the tourniquet was on the entire time. Six hours after the

FIGURE 9. Six-month postoperative lateral radiograph of the case shown in Fig 8: arthroscopic reduction and fixation has been applied and there is complete union.

TABLE 2. *Preoperative, Intraoperative, and Postoperative Findings*

Patient	Age (yr)	Type of Injury	Side Involved	Type of Fracture	Lack of Flexion	Lack of Extension	Associated ACL Tear	Complications
Adolescent								
1	11	Falling	R	II	5°	0°	—	Bursitis over screw
2	9	Falling off bike	L	III	15°	2°	—	Intra-articular adhesions
3	10	Unknown	L	III	8°	2°	—	None
4	14	Sports	R	II	0°	0°	—	None
5	11	Sports	R	III	9°	3°	—	Bursitis over screw
6		Falling off bike	L	III	10°	3°	—	None
7		Falling	L	II	7°	3°	Interstitial	None
8		Traffic accident	R	III	10°	5°	—	None
Adult								
9	33	Unknown	R	III	40°	10°	Present	Arthrofibrosis + limitation of motion
10	29	Traffic	R	III	18°	5°	Absent	Intra-articular adhesions
11	27	Sports	R	III	13°	2°	Absent	None
12	18	Sports	R	II	5°	0°	Interstitial	None
13		Sports	R	III	18°	5°	—	None
14		Sports	R	III	20°	5°	—	Intra-articular adhesions
15	37	Sports	L	II	5°	0°	—	None
16	39	Falling	R	III	20°	5°	—	Intra-articular adhesions
17	23	Sports	L	III	15°	3°	—	None
18		Traffic accident	R	III	15°	3°	Interstitial	None
19		Sports	R	III	10°	0°	—	None
20		Traffic accident	L	II	15°	4°	—	None
21		Unknown	L	III	15°	3°	—	None

operation, vascular insufficiency at the ipsilateral extremity developed, the dorsalis pedis pulse was unable to be palpated, and circulation at the dorsum of the foot was impaired. As collateral circulation developed, the nutrition of the foot became better but deep venous insufficiency persisted. Delaying the initiation of rehabilitation because of vascular compromise and lack of patient cooperation resulted in arthrofibrosis of the knee. This was the worst result in our series with a 40° loss of flexion. Further investigation of this

FIGURE 10. Preoperative MRI of type III eminentia fracture developing after sports trauma in a highly competitive 27-year-old male patient.

FIGURE 11. Radiograph of the case shown in Fig 10: arthroscopic reduction and fixation has been applied and complete union is seen. Small calcified spots seen in the joint are considered to be intra-articular adhesions.

FIGURE 12. Case in Fig 10: 6 months after the first operation, screws are removed and intra-articular adhesions debrided.

patient revealed alcohol abuse and previously existing vascular deficiencies.

The 2 late complications involved tenderness over the screw head at the tibial metaphysis. Removal of the screw and the accompanying localized bursitis successfully solved the problem.

DISCUSSION

Intercondylar eminence fractures should always be carefully looked for in traumatic knee injuries of adolescents. Four of our patients had been previously misdiagnosed at other institutions. Therefore, in addition to clinical findings, careful radiographic examination and MRI, which reveal fracture fragments that can be larger than they appear on radiographs and may be suitable for suture or screw fixation, are essential. In their study, Taser et al.[5] also placed great emphasis on this fact.

For guidance to treatment, nearly all authors agree on the advantages of the Meyers-McKeever classification.[5,10,13-16] Good results have been reported with 6 to 8 weeks of immobilization in the treatment of type I fractures.[2,17] Some authors advocate hyperextension treatment in type II fractures. But Meyers and McKeever stated that closed reduction maneuvers were dangerous and that a type II fracture could be displaced and become a type III fracture.[2] They also emphasized that most of these fractures in adults are type III. A study by McLennan[18] showed that the condyles of the femur are in contact with the anterior tibial eminence and thus hyperextension does not provide reduction. Agreeing with these and to avoid the disadvantages of a long immobilization period, arthroscopic treatment is preferred in our active patients. Conservative treatment could also increase the losses in range of motion. Because of this, arthroscopic surgical treatment was performed for the type II fractures in our athletic patients. The presence of stability among this population is an important guide for early rehabilitation.

Undoubtedly, type III fractures including both the A and B subgroups require fixation of the fragments.[9,15] The necessity of surgical treatment is brought out by the risk of nonunion or malunion of the fragment and changes in congruity or localization of the ACL. Matthews and Geissler[14] emphasized the importance of the integrity and length of the ACL. Anterior laxity of the knee and loss of extension are expected results with conservative treatment of the type III fractures. Today, the treatment of choice is arthroscopic reduction and internal fixation in patients with unsuccessful results after closed reduction, or in patients with displaced fractures, delayed union, and malunion. Successful results have been reported with anatomic reduction either by arthrotomy or by arthroscopy.[6,19-21] Another advantage of arthroscopy in these patients is the possibility to differentiate between types II and III fractures. However, despite the agreement on the superiority of arthroscopic treatment, there are few studies on the technique.[22] We assume that the reason for this is the difficulty in performing the procedure.

We aimed to determine the ease in applying the techniques described in the literature. As we gained more experience, we were able to perform reduction and fixation more easily and in a relatively shorter time. The technique provides elimination under direct visualization of interposed fragments and soft tissue, including debris or meniscal structures that may be preventing proper reduction of the fracture, especially in fragmented type III fractures.[2,8] At the same time, associated pathologies can be treated. In addition to the advantage of being able to treat multiple injuries, the lack of harm to the extensor mechanism, as occurs with arthrotomy, decreases morbidity and provides an easy rehabilitation period.[19] McLennan[8] identified 14 lateral meniscal tears in 35 cases of type III fractures. Other reported associated injuries include medial meniscal tears,[23] medial and lateral collateral ligament injuries,[19] and tibial plateau or osteochondral fractures.[17] We have determined the incidence rate of additional injury to be 38.1% (8 cases).

Although our series does not confirm this, anterior eminence fractures occur more commonly in children and adolescents and very often are the result of falling off a bicycle, the mechanism of injury usually being hyperextension and deceleration.[10,17] For the 8 adolescent cases in our series, the technique we used included ACL fixation with sutures as was recommended by Berg,[10] Medler and Jansson,[15] and Matthews and Geissler.[14] In this way, there is minimal harm to the physis of the adolescent knee. We do not recommend transepiphyseal fixation because of the risk of anterior growth arrest and hyperextension deformity of the knee, although we did not observe this in any of our patients.[24] Berg and Lachman, using KT-1000 measurements, have shown that suture fixation prevents ACL laxity.[10] But because rehabilitation studies are more difficult to apply to children, the incidence of loss of motion and arthrofibrosis is high with this technique. We believe that stable fixation and early motion will decrease the incidence of these complications. Suture fixation is especially advantageous in fragmented fractures by providing stable fixation at the ACL base and by eliminating the need for a second operation to remove the implant.[11,21] Suture punch tools, produced originally for different purposes, may help in suture fixation of the ACL. Although the surgical technique is satisfactory in gaining ACL stability and fracture union in children and adolescents, difficulties in cooperation during the rehabilitation period result in discouraging long-term results concerning range of motion.

Although Wiley and Baxter[17] have reported that avulsion fractures of the tibial eminence are rare, increasing participation in sports activities has resulted in an increase in the incidence of these fractures in physically active young people.[2,17,23] In adults, these fractures are commonly caused by traffic accidents.[11] The adults in our series were either highly competitive in sports or had been in traffic accidents. As Meyers and McKeever have stated most of the fractures in this group are type III.[2] Kendall et al. have reported that the treatment results of adult eminence fractures are not as satisfactory as in the pediatric group.[16]

The overall results following adequate reduction of the tibial spine are good to excellent.[2,25] Sequelae following treatment of tibial spine fractures, such as residual ACL laxity and loss of terminal knee extension, have been reported.[17,26] Loss of terminal extension may be due to the lengthening and hypertrophy of the tibial spine secondary to residual displacement and hyperemia, which can create a bony block to extension. This was reported to be a 4° to 15° loss of extension in Wiley and Baxter's series[17] and was found not to be significant.[17,26]

The more favorable results with decreased extension loss obtained in our series depend on the surgical treatment and satisfactory reduction. Loss in range of motion of the knee observed in conservatively treated eminentia fractures may be due to malunion, which results in a mass in the intercondylar notch and produces symptoms such as the cyclops syndrome.[20,27]

The technique we use in the treatment of eminence fractures mainly depends on the principle of anatomic reduction and stable fixation of the fracture arthro-

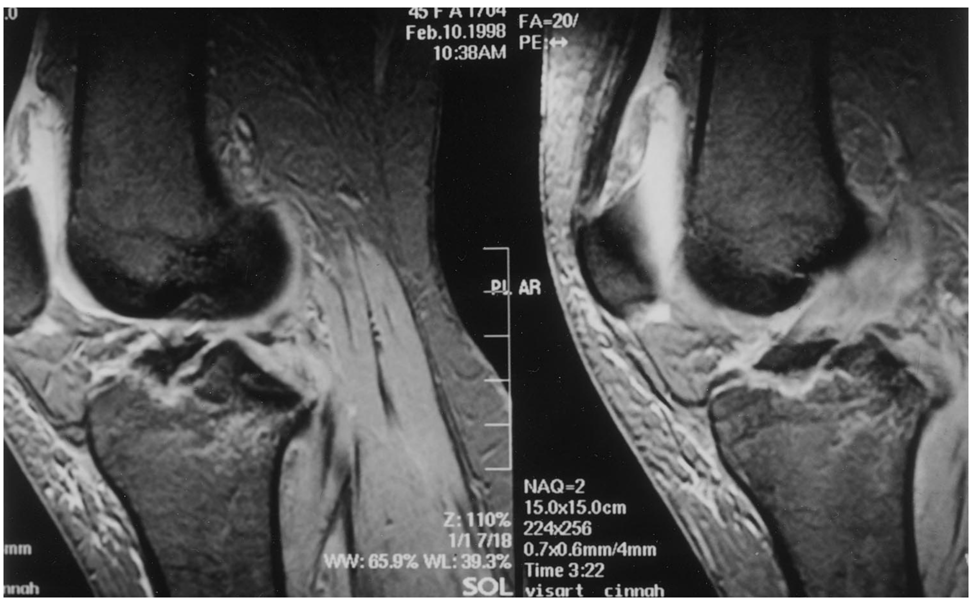

FIGURE 13. Preoperative sagittal MRI view of the case of a 31-year-old woman with eminentia intercondylaris fracture.

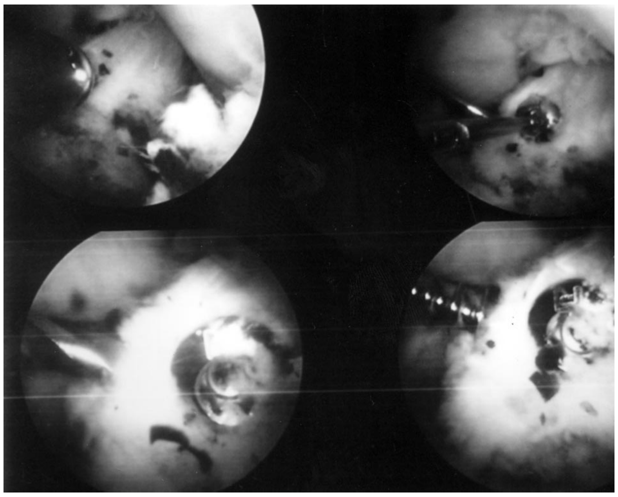

FIGURE 14. Case in Fig 13: arthroscopic view of the fragment reduced and fixed with a cannulated screw over a K-wire via the anteromedial superior portal and with a second screw set via the anterolateral superior portal.

scopically (Figs 13-15). With the help of this technique, the original length of the ACL is protected and stability of the knee in all axes is obtained. We believe that of all the fixation techniques, the most reliable in adults is screw fixation. But for fractures to be suitable for screw fixation, they should be nonfragmented and the size of the fragment should be at least 3 times of that of the screw head.[28] This means the fragment should be at least 15 mm in adults. Initially, we were using 4-mm AO/ASIF mini-cancellous screws but, in the last 7 cases, we used 4-mm cannulated screws.[11] The time for the whole procedure decreased as we gained familiarity with the technique and because we used K-wires for guidance of the cannulated screws.

Arthroscopic retrograde screw fixation as described by VanLoon and Mante,[9] and the antegrade method by Berg,[10] are also reliable fixation techniques. They used mini AO/ASIF screws in their techniques, which lacked the advantages of cannulated screws especially for small and thin fragments. The stability obtained with the help of arthroscopic techniques does not carry the risk of reduction loss and thus allows early rehabilitation; but beside satisfactory stability, technical applicability is also required. Although the arthroscopic fixation described by McLennan[8] and Loon and Mante[9] was successful, the technique was found to be difficult to perform.

An alternative to screw fixation is dynamic staple fixation. The problem of unsatisfactory fixation can be solved with the help of this dynamic staple. It has good fixation rigidity, but has the disadvantage of the difficulty encountered when using the guide that must be passed through the medial portal.[13] Other disadvantages, which are caused by the size of the implant, include difficulty in terminal extension of the knee and the risk of further fragmentation of the fractured eminentia.

As is always possible, we experienced 1 serious complication during the progress of our learning curve. We encountered severe peripheral vascular insufficiency in the case of the adult who smoked and was an alcoholic. Delay in his rehabilitation resulted in arthrofibrosis. A revision procedure could not be performed because of the peripheral vascular status. This case has been an important factor in increasing our average rate of loss of movement.

CONCLUSION

The diagnosis and treatment of associated injuries is possible with arthroscopic techniques. With the technique we describe, anatomic reduction, stable internal fixation, and stability in all planes can be achieved, protecting the original length of the ACL. Meanwhile, growth plates can be protected in adolescents and children. The technique also has the advantages of minimal surgical intervention and early rehabilitation. However, the technique requires experience for easier application. We believe standardization of portals and use of cannulated screws under the guidance of K-wires make the procedure less time consuming and more applicable.

FIGURE 15. Case in Fig 13: 6-month postoperative radiograph showing complete union.

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