pagepress

Arthroscopic treatment of tibial intercondylar eminence fractures in skeletally immature patients with bioabsorbable nails

Francesco M. Uboldi, Paolo Trezza, Elena Panuccio, Antonio Memeo

ASST Gaetano Pini – CTO, Pediatric Orthopedic Department, Milan, Italy

Correspondence: Francesco M. Uboldi, ASST Gaetano Pini – CTO, Pediatric Orthopedic Department, Milan, Italy.
E-mail: fraubo@gmail.com

Key word: Tibial intercondylar eminence; paediatric articular fractures; knee arthroscopy; SmartNails.

Funding: None.

Contributions: FMU, PT, EP and AM made the conception and the design of the work and drafted the first version of the manuscript. Each author made substantial contributions to the design of the work as well as to the acquisition, analysis, and interpretation of data. All authors also substantively revised the work and approved the submitted version (and any substantially modified version that involves the author's contribution to the study), and agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even those in which the author was not personally involved, are appropriately investigated and resolved, and the resolution documented in literature. All authors read and approved the final manuscript.

Conflict of interests: The authors declare no conflict of interests.

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate: All patients accepted the proposed treatment and follow-up after adequate information and gave written consent. The study and follow-up, respecting the criteria of the Declaration of Helsinki, were approved by the Institutional Scientific Board of ASST Gaetano Pini - CTO, that accepted the proposal of the study, and all selected patients were properly informed before surgery about the treatment and follow-up visits after discharge.

Informed consent: Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Received for publication: 30 September 2022.
Revision received: 4 October 2022.
Accepted for publication: 4 October 2022.

Licensee PAGEPress, Italy
La Pediatria Medica e Chirurgica 2022; 44(s1):299
doi:10.4081/pmc.2022.299

Abstract

Fractures involving tibial eminence caused by ACL avulsion lesion most frequently occur paediatric patients. Satisfactory reduction in displaced fractures cannot be achieved through conservative treatment, while arthroscopy-assisted fixation technique represents the gold standard to reduce and to fix articular fractures and several effective implants have been used to treat this kind of fractures. In our retrospective study, we proposed a different arthroscopic technique to fix Type II and Type III tibial eminence fractures by using bioabsorbable nails. Nineteen patients, aged 6 to 13 years were treated with arthroscopic reduction and fixation of the fragment using bioabsorbable nails. At 6-month follow-up, all patients showed a decrease of less than 2mm of the anterior edge. All patients at maximum follow-up reached a full knee flexion/extension. IKDC subjective mean score at six-month was 88.14.2 points (range 80-95; $p<0.01$). For what concerns the Tegner Activity Scale, the mean value of 5.51 (range 3-7) prior to the surgery changed into 5.10.9 (range 3-6) at 6 months. No inflammatory reactions were reported and all fractures healed without complications. The objective IKDC grade A was reported in 18 patients and grade B in one patient, having a "nearly normal" range of motion item (92% compared to contralateral). Results can be compared to other surgical procedures described in the literature, having the same fast learning curve increase and limited complications, beside the fact that a second operation for metallic implants removal was avoided.

Introduction

The tibial intercondylar eminence acting as the Anterior Cruciate Ligament (ACL) insertion site and could be fractured due to ACL avulsion lesion. These fractures occur most frequently in paediatric population (peak of incidence is between 8 and 14 years of age), representing about 2% of all paediatric knee injuries.[1] The avulsion fracture occurs at the incompletely ossified tibial epiphysis that represents the weaker point (Figure 1 and 2).

As associated signs and symptoms are similar to ACL rupture, performing diagnostic exams such as X-ray or CT is mandatory in order to make a correct differential diagnosis.

Meyers and McKeever proposed the first classification system of tibial eminence fractures in 1959. They divided all fractures in 3 different patterns: non-displaced (Type I), partially displaced or hinged (Type II) and completely displaced (Type III).[2] Zaricznyj later described the displaced and comminute fractures (Type IV).

Type I and Type II fractures (displacement <2mm) can be treated by close reduction and cast immobilization. Immobilization must be done in extension or in semi-flexion at 20° and must be maintained for 5-6 weeks.

Displaced fractures (Type II >2mm, Type III and IV) cannot achieve a good reduction by conservative treatment because the severe grade of displacement may lead the interposition of the intermeniscal ligament between the tibial plate and the fractured fragment.

Arthroscopy-assisted fixation technique represent the gold standard to reduce and to fix articular fractures and several effective implants have been used to treat this kind of fractures, including screw, suture, anchor and K-wire.

In our prospective study, we proposed a different arthroscopic technique to fix Type II and Type III tibial eminence fractures by using bioabsorbable nails, evaluating the effectiveness of our technique and the postoperative outcomes in our patients.

Materials and Methods

The study evaluated all skeletally immature patients who underwent an arthroscopic tibial intercondylar eminence fracture reduction and fixation with bioabsorbable nails from 2015 to 2019. Nineteen patients (11 female and 8 male) underwent surgery, the mean age was 10 years (6-13), a Type II fracture was diagnosed in 5 patients and a Type III fracture in 14.

Surgical technique e rehabilitation protocol

By standard knee arthroscopy view the diagnostic fracture confirmation phase was carried on. It is essential to evaluate all the structures that could potentially be interposed and make difficult an anatomical reduction.

With an accessory anteromedial/midpatellar portal a 3 mm diameter drill guide was then introduced into the joint and the first bioabsorbable nail "SmartNail" (ConMed Linvatec, Largo, FL, USA) was tapped down to the right measure (Figure 3). The polylactide polymer SmartNails are constructed proximally with a head and distally with barbs. This provides compression during fracture healing.

We then made an accessory anterolateral portal, and with a similar technique we tapped down one or more nails if necessary. The knee was then immobilized in extension or slight flexion (20°) using a cast for 3 weeks. Weight bearing is not allowed during all this period.

After 3 weeks the patient is examined by X-Ray and the cast can be removed. After cast removal, all patients are required to use an articulated knee brace that allows 0-60° of flexion for 2 additional weeks. Patients can start a progressive weight bearing with two crutches.

Objective and subjective knee evaluation

The patients were clinically examined and completed the Subjective International Knee Documentation Committee (IKDC) questionnaires and the Tegner Activity Scale (TAS). Clinical examination was performed according to the Objective IKDC evaluation form, angular deformity and growth disturbance were assessed clinically.

Patients were postoperatively evaluated at 3 and 6 months and at maximum possible follow-up. No loss to follow-up was reported, maximum mean follow-up was of 27 months (6-60).

Preoperative and postoperative x-rays were evaluated.

Results

Patients' demographic and clinical data are shown in Table 1 and 2.

Neither cases of infections, pseudoarthrosis, nor inflammatory reactions were. At 6-month follow-up, all patients showed a

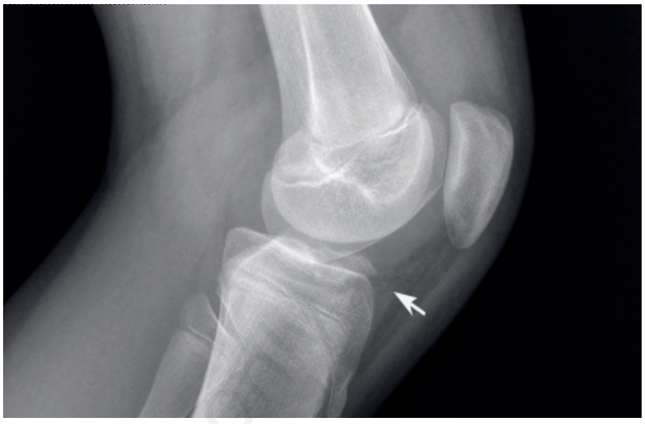

Figure 1. Conventional X-ray of the knee showing a fracture (Meyers and McKeever II) of the intercondylar eminence.

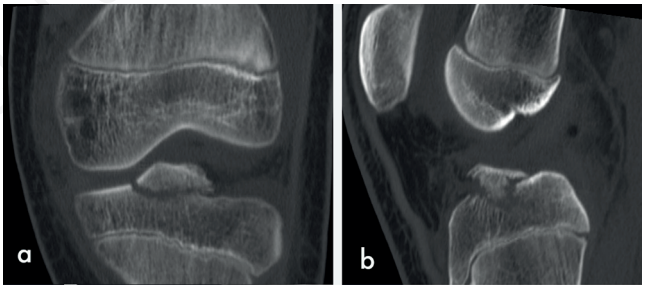

Figure 2. Pre-operative computed tomography scan of the knee showing the fracture of the intercondylar eminence (a: reconstruction of the coronal view; b: sagittal view).

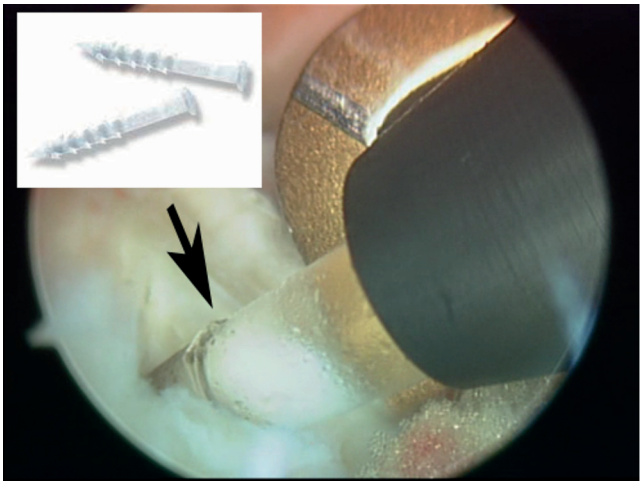

Figure 3. Arthroscopic view of knee and the fragment fixation using the guide device for placement of the bioabsorbable nail.

decrease of less than 2mm of the anterior edge of the tibial eminence, mean 10.8 (0-2). All patients at maximum follow-up reached a full knee flexion/extension (>90% compared to contralateral). No patient showed signs of alteration of growth (length discrepancy or malalignment).

S-IKDC mean score at 3-month after surgery was 70.67 points (54-79) and at 6-month it was 88.14.2 points (80-95) with p<0.01.

At maximum follow-up mean value was 884.5 (80-95), without any significant difference after the 6th month. For what concerns the Tegner Activity Scale, the mean value of 5.51 (3-7) prior to the surgery changed into a mean value of 3.10.7 (2-4) at 3 months (p<0.01); then it showed to a mean value of 5.10.9 (3-6)

Table 1. Demografic data.

Pt	Sex	Age at injury (y)	Max Follow-up (m)	Fracture Type	Activity level before injury	Injury	Implants	Surgery time (m)
1	F	9	6	3	6	Ski	1 SN 1,5x16mm	35
2	M	13	16	2	6	Ski	1 SN	45
3	M	11	47	3	3	Bike	2 SN 16mm	40
4	F	10	27	3	4	Ski	2 SN 2,4x16mm	35
5	M	13	36	3	7	Bike	2 SN 16mm	35
6	M	13	6	3	7	Soccer	1 SN 1,5x16mm	25
7	F	6	25	3	5	Ski	2 SN 2,4x16mm	35
8	F	9	6	2	6	Ski	2 SN	45
9	F	10	60	2	5	Ski	2 SN 16mm	50
10	M	9	53	3	5	Ski	2 SN 16mm	30
11	F	6	7	3	4	Dance	2 SN 2,4x16mm + 1 SN 2,4x25mm	60
12	F	12	49	2	6	Ski	2 SN 16mm	48
13	F	11	48	3	6	Ski	2 SN 16mm	30
14	M	13	23	3	6	Soccer	2 SN 16mm	40
15	M	12	34	2	6	Soccer	2 SN 16mm	35
16	F	13	6	3	7	Ski	3 SN	45
17	F	12	39	3	6	SKi	2 SN 16mm	30
18	F	9	6	3	5	Ski	2 SN 1,5x16mm	60
19	M	15	6	3	6	Ski	2 SN 1,5x16mm	35

Table 2. Results data.

Pt	IKDC Subjective			Tegner			IKDC Objective		Displacement (mm)
	3 m	6 m	Max F-U	3 m	6 m	Max F-U	3 m	6 m	
1	79	88	88	3	5	5	A	A	1
2	72	92	91	4	6	6	A	A	0
3	54	82	89	2	3	4	B	B	1
4	74	87	91	3	4	4	A	A	2
5	71	90	93	4	5	7	A	A	0
6	68	87	87	3	6	6	B	A	0
7	72	80	86	3	5	5	A	A	1
8	79	92	92	4	5	5	A	A	0
9	67	81	89	3	4	5	B	A	0
10	72	89	94	3	5	6	A	A	0
11	77	93	93	2	4	4	B	A	1
12	71	90	92	3	5	6	A	A	1
13	69	86	85	3	6	6	B	A	2
14	73	93	95	4	6	7	A	A	0
15	79	95	95	3	6	7	A	A	0
16	77	90	90	4	6	6	A	A	2
17	63	85	92	3	5	7	B	A	1
18	56	80	80	2	5	5	A	A	2
19	68	88	88	4	6	6	A	A	1

at 6 months ($p<0.01$) and a mean level of 5.61 (4-7) at maximum follow-up. All patients resumed sport activities.

The objective IKDC grading at 3 months was evaluated as grade A in 13 patients and grade B in six patients; at six months, 18 patients showed a grade A and one patients reached a B grade, with a "nearly normal" range of motion item with $p<0,05$ comparing the two evaluations.

Discussion

One of the main difficulties when dealing with immature skeleton is the biological damage in tissues still undergoing modification and the bigger chondral component, which can often determine a diagnostic delay or difficulties in treatment.[3]

A controversial point between the surgical treatment and the nonsurgical treatment was the residual knee laxity, moreover, this laxity does not correlate to the quality of the fracture reduction but with the plastic deformation of the ACL, which occurs just before the avulsion. Gronkvist *et al.* reported a spontaneous correction of the laxity by residual bone growth potential in children under the age of ten.[4] No differences were noticed in results from our patients' group between the subgroup of patients <10 years of age and the subgroup of patients ≥10 ($p>0.05$).

Similarly to Liljeros *et al.*,[5] an anterior-posterior stability equal to or less than 2mm was obtained in 18 patients, with only one patient showing a value between 3 and 5mm, compared to contralateral knee.

Many different treatment methods have been proposed for surgical stages in this pathology, both open and arthroscopic; despite this, there is no unanimity on the treatment of choice.

As far as our study is concerned, we found that using bioabsorbable nails through arthroscopy is an efficient technique for reduction and synthesis in tibial eminence fractures, ensuring sport resumption by six months. The use of biodegradable devices allows direct compression of the fracture without requiring an intervention for their removal.[6]

Each technique has its pros and cons, although many authors advocated and carried out extensively that arthroscopic treatment leads to lower comorbidity, early mobilization and shorter hospital stay[7] while still allowing for hematoma evacuation and visualization of the lesion, with the advantage of cleaning bone fragments.

The risk of growth disturbance is often discussed when the surgical technique includes drilling across the fracture line in skeletally immature patients with ATS fractures. The use of cannulated screws, sutures, and k-wire, determine a greater risk of damaging the growth cartilage, directly or due to tunnel predrilling.[5,6] SmartNails use is unlikely to reach the growth cartilage and the size of the holes would not show any clinical impact on the growth cartilage considering the size of the nails (1.5 mm).

The learning curve in the use of the SmartNails system is very steep, as the technique is based on a guided system with a determined perforation depth and nails auto-retention.

Moreover, due to the low incidence of tibial eminence avulsion fracture, the sample size in the present study is relatively small which may increase the possibility of type II error. A large number of cases are needed for further studies. A multi-center study may be a powerful research tool.

Conclusions

The use of SmartNails is a reasonable procedure in skeletally immature patients with Type II and III anterior tibial spine fractures. The outcome is comparable to other published surgical procedures. A second surgery for removal of other implants is avoided.

References

1. Melugin HP, Desai VS, Camp CL, et al. Do tibial eminence fractures and anterior cruciate ligament tears have similar outcomes? Orthop J Sport Med 2018;6:1-7.
2. Meyers MH, McKeever FM. Fracture of the intercondylar eminence of the tibia. J Bone Jt Surg Am 1959;41-A:209–222.
3. Chotel F, Seil R, Greiner P, et al. The difficult diagnosis of cartilaginous tibial eminence fractures in young children. Knee Surgery Sport Traumatol Arthrosc 2014;22:1511-6.
4. Gronkvist H, Hirsch G, Johansson L. Fracture of the anterior tibial spine in children. J Pediatr Orthop 1984;4:465–8.
5. Liljeros K, Werner S, Janarv PM. Arthroscopic fixation of anterior tibial spine fractures with bioabsorbable nails in skeletally immature patients. Am J Sports Med 2009;37:923-8.
6. Mahar AT, Duncan D, Oka R, et al. Biomechanical comparison of four different fixation techniques for pediatric tibial eminence avulsion fractures. J Pediatr Orthop 2008;28:159-62.
7. Wouters DB, de Graaf JS, Hemmer PH, et al. The arthroscopic treatment of displaced tibial spine fractures in children and adolescents using Meniscus Arrows®. Knee Surgery, Sport Traumatol Arthrosc 2011;19:736-9.