Outcomes after arthroscopic fixation of tibial eminence fractures with bioabsorbable nails in skeletally immature patients

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The aim of this paper is to report the outcomes and any complications with arthroscopic bioabsorbable nail fixation of tibial eminence fractures in skeletally immature patients. We retrospectively reviewed all surgically treated tibial eminence fractures treated by a single surgeon and seven patients were identified with a minimum 2-year follow-up. Mean deficits of flexion and extension were minimal. Satisfactory Tegner levels, Lysholm knee scores, and International Knee Documentation Committee subjective scores were reported. Arthroscopic fixation of tibial eminence fractures with bioabsorbable nails yields satisfactory outcomes for this uncommon injury and obviates the need for future hardware removal. *J Pediatr Orthop B* 00:000–000 Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

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Introduction

First described by Poncet [1], tibial eminence fractures are uncommon injuries that predominantly occur in skeletally immature patients. They represent a bony avulsion of the anterior cruciate ligament (ACL) from its insertion site at the tibial intercondylar eminence. Meyers and McKeever [2] developed a classification system for these fractures. Type I fractures are minimally displaced. Type II fractures involve displacement of the fragment anteriorly, but maintain bony contact posteriorly, which may act as a hinge. Type III fractures are completely displaced. This classification system was modified by Zaricznyj [3] to include comminuted fractures, which are labeled type IV fractures. Treatment for type I fractures is nonoperative, whereas type III and IV fractures are treated with reduction and fixation. Although controversy surrounds the management of type II fractures, most are surgically treated if casting in extension fails to reduce the fragment.

Several fixation methods have been reported in the literature. Some authors have advocated metallic screw fixation with or without a washer, suture fixation, bioabsorbable nail fixation, intra-articular button, or a hybrid construct [4–21]. Although several biomechanical studies have been published comparing many of these techniques [22–24], it remains unclear as to which construct will optimize stability and outcomes.

Although there have been studies on outcomes after arthroscopic fixation of tibial eminence fractures, to date, there has been only one reported case series on outcomes after arthroscopic fixation with bioabsorbable nails [13]. The aim of this paper is to report the outcomes and any associated complications with arthroscopic bioabsorbable nail fixation of tibial eminence fractures in skeletally immature patients.

Patients and methods

After institutional review board approval at our institution (protocol number X150319007), we retrospectively reviewed all surgically treated tibial eminence fractures treated by a single pediatric sports trained orthopedic surgeon between August 2011 and July 2014. Exclusion criteria included patients who were skeletally mature or had less than a 2-year follow-up.

The patients were followed clinically postoperatively. The mean follow-up for patients was 31 (range: 24–36) months. At the final follow-up, a complete knee examination was performed including range of motion using a goniometer, Lachman test, anterior drawer test, and pivot shift test. Angular deformity and growth disturbance were assessed clinically. Also, patients were asked to fill out forms to compute Tegner activity levels, Lysholm scores, and International Knee Documentation Committee (IKDC) subjective scores. The IKDC subjective score was calculated by dividing the computed score by the possible maximum score (87) and multiplying this value by 100.

Surgical technique

General anesthesia was used in all cases. A tourniquet was placed before prepping the leg. Standard anterolateral and anteromedial arthroscopy portals were used. A diagnostic arthroscopy was first performed. To enable adequate visualization of the anterior aspect of the

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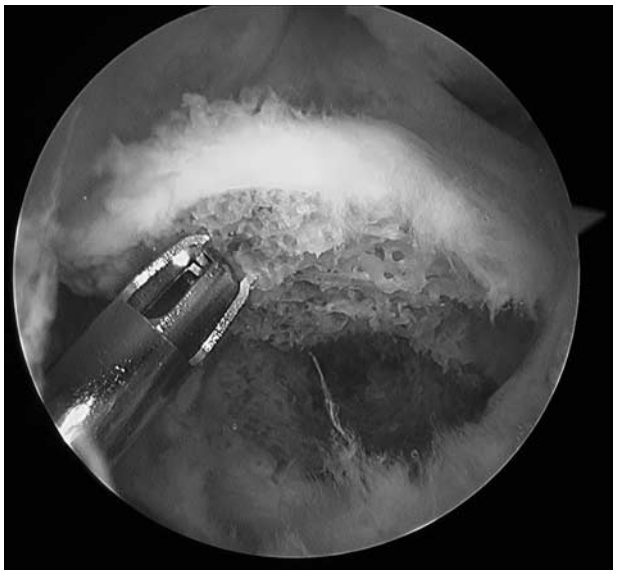
Fig. 1



Arthroscopic view of the fracture bed, which is being elevated and prepared before fragment reduction.

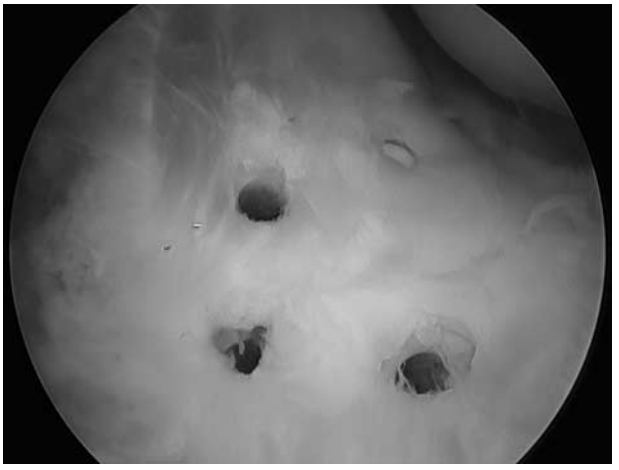
Fig. 2

Arthroscopic view of knee and the drill using a guide device for placement of the bioabsorbable nail.

fracture bed site, multiple provisional sutures were passed circumferentially around the intermeniscal ligament using a system of spinal needles, such that weighted surgical instruments could be hung from the sutures to provide retraction. This allowed not only complete visualization of the fracture site but also prevented the intermeniscal ligament from impeding reduction. Once the tibial eminence fracture was confirmed, an oscillating shaver and small curette was used to debride the fracture bed and any interposed soft tissue (Fig. 1). An arthroscopic probe was then used to manipulate the fragment and help reduce it. Once the fragment was reduced, K-wires were carefully placed antegrade along the superomedial trochlea into the fragment to maintain provisional reduction. An accessory portal was created over the superomedial aspect of the patella, allowing entry of a guide device for placement of the nails (Fig. 2). Drilling was accomplished with the provided wire, followed by placement of the 1.6 mm bioabsorbable LactoNail (Arthrotek, Warsaw, Indiana, USA). The lengths varied from 14 to 22 mm dependent on the depth of the fracture fragment and the distance to the physis. The number of bioabsorbable nails used ranged from 4 to 8 and was based on the surgeon's discretion with the goal of achieving optimal fixation. Figure 3 shows the LactoNails in place with the fracture reduced.

One case involved a malunion of a tibial eminence fracture. Using a combination of curettes, elevator, and small shaver, the interposed malunited callus was removed carefully to allow for mobilization of the displaced fragment. After removal of the excess bone formation, an appropriate fracture bed was created, allowing the displaced spine fragment to be hinged into appropriate alignment.

Fig. 3



Arthroscopic view of the tibial eminence with bioabsorbable nails in place and fracture reduced.

Postoperatively, the knees were immobilized in a cylinder cast for 3 weeks, with restricted weight bearing. Conversion to a hinged knee brace and initiation of physical therapy commenced upon removal of the cast. Progressive range of motion, including active and active assist closed chain activities, was accomplished with the

help of a physical therapist, and crutches were discontinued near week 6 following confirmation of return of quadriceps function and adequate healing on radiographs. Evaluation at 12 weeks with radiographs and clinical examination allowed for discussion of return to play timeline.

Results

A total of seven patients were identified who were surgically treated for tibial eminence fractures with a minimum 2-year follow-up. All patients were skeletally immature. The average age of the patients on the date of surgery was 11.6 (range: 8–15) years.

Mechanisms of injury included bicycle injury (two patients), skateboard injury (two patients), football tackle injury (one patient), trampoline injury (one patient), and a fall (one patient).

Six sustained a type III tibial eminence fracture and one sustained a type II fracture. Two patients had concurrent meniscal tears that were debrided at the time of surgery. One of these patients also underwent chondroplasty of the tibial plateau with a microfracture procedure. All except one patient were operated on acutely (within 1 week). No significant comminution was noted at the time of surgery. One patient presented with a malunion three months after being treated conservatively at an outside hospital.

All seven patients showed healing of their tibial eminence fractures radiographically. There were no clinical signs of growth disturbances or angular deformities about the knee. With respect to range of motion, all patients had a flexion deficit of less than 10°, with a mean flexion deficit of $2.6° \pm 3.3°$. Only one patient had an extension deficit, which was 3°. Lachman, anterior drawer, and pivot shift tests were performed at the final follow-up visit and all patients showed stable and symmetric knee exams. The results of Lachman and anterior drawer testing are shown in Table 1 (grade I defined as anterior translation of 1–5 mm, grade II as 6–10 mm, and grade III as > 10 mm, with A corresponding to a firm end point and B corresponding to a soft or absent end point). All pivot shift testing produced a grade 0, which is considered normal, with no reduction or shift noted [25]. With respect to activity level, all except one patient maintained his Tegner activity level. This patient dropped a level. In terms of Lysholm knee scores, four patients reported excellent outcomes (95–100 points) and three patients reported good outcomes (84–94 points). The mean Lysholm score was 95.6 ± 5.2. The mean IKDC subjective score at the final follow-up was 97.3 ± 3.5. The above-stated results along with patient demographics are summarized in Table 1.

There was a complication of arthrofibrosis, defined as the loss of knee flexion beyond 90°, in one patient. This patient required manipulation under anesthesia at

Table 1 Patient demographic characteristics and clinical results

Patient no.	Sex	Age at initial injury (years)	Mechanism	Fracture type	Complication or subsequent surgery	Lachman	Anterior drawer	Flexion deficit (deg.)	Extension deficit (deg.)	Tegner activity level[a]	Lysholm score	IKDC subjective score
1	Male	8	Bicycle	III	Arthrofibrosis – manipulation under anesthesia	IA	IA	0	0	9/9	90	97
2	Male	12	Trampoline	III	No	IA	IA	6	0	6/6	99	92
3	Male	13	Skateboard	III	No	IA	IA	1	0	9/9	90	93
4	Male	10	Football	III	No	IIA	IIA	3	0	9/9	100	100
5	Male	15	Skateboard	III	No	IA	IA	8	0	10/9	100	100
6	Male	12	Bicycle	III	No	IA	IA	0	0	7/7	100	100
7	Male	11	Fall	II	No	IA	IA	0	3	7/7	90	99

IKDC, International Knee Documentation Committee.
[a]Preinjury/postinjury level.

~6 weeks postoperatively, but eventually achieved symmetric knee range of motion. The exact etiology of arthrofibrosis in this patient is unclear, but this patient did not require any prolonged immobilization because of insecure fixation. There were no infections and no repeat arthroscopy procedures were performed.

Discussion

Overall, we found that arthroscopic fixation of type II and III tibial eminence fractures with bioabsorbable nails achieves satisfactory outcomes in skeletally immature patients.

To date, Liljeros *et al.* [13] is the only group to have published outcomes after using bioabsorbable nail fixation. In their study, they evaluated the outcomes of 13 patients at 2–5 years postoperatively. Most fractures were type III. With the exception of one patient, Lysholm scores were excellent or good. Extension deficits of 5° were recorded in four patients and flexion deficits between 5° and 10° were recorded in three patients. Our results are comparable with those of this previous study.

Multiple studies have been published with respect to other fixation techniques for tibial eminence fractures. Carro *et al.* [6] reported the results of seven patients with type II and type III fractures treated with sutures. Although no functional outcomes were reported, all fractures healed. In three knees, there was a 5° extension lag. Kocher *et al.* [12] published a case series on six skeletally immature patients with type III fractures treated with 3.5 mm cannulated screw fixation. Functionally, the mean Lysholm score was 99.5 and the mean Tegner activity level was 8.7 at the final follow-up. A recent study by Memisoglu *et al.* [21] describes fixation with an intra-articular button. At a mean follow-up of 69 months, patients had an average Lysholm score of 95.7 and an average IKDC subjective score of 94.3.

One of the main advantages of using bioabsorbable nails over metallic screws is avoiding the potential need for future screw removal. Furthermore, in the future, if the patient sustains a mid-substance ACL tear, one would not need to worry about the screw hindering the tibial tunnel pathway. Multiple authors have published a high rate of screw removal postoperatively. May *et al.* [15] reported on 22 patients treated for tibial eminence fractures. Of the seven patients treated with screw fixation, four underwent hardware removal at a later date. Similarly, Senekovic *et al.* [18] published the results of 22 patients treated with a cannulated screw or a cannulated screw with washer. The implants were removed in all patients except one. In the series by Kocher *et al.* [12], all six patients underwent screw removal between 8 and 12 weeks postoperatively. The authors stated that they wished to avoid permanent intra-articular metallic hardware in young patients.

A common alternative to screw fixation is suture fixation. However, suture fixation may lead to higher rates of arthrofibrosis. In a meta-analysis by Gans *et al.* [26], 0% of those treated with screw fixation developed arthrofibrosis compared with 6.3% of those in treated with suture fixation. Theoretically, the passing of sutures from extra-articular to intra-articular may inadvertently bind up the capsular layer in the fixation, thus increasing the risk for arthrofibrosis [8].

Although multiple biomechanical studies have compared various methods of fixation of tibial eminence fractures [22–24], only one study has included bioabsorbable nails. Mahar *et al.* [23] compared nonabsorbable sutures, bioabsorbable nails, a single resorbable screw, and a single metallic screw in a simulated fracture in a skeletally immature bovine knee. The authors did not find any statistically significant difference in biomechanical strength between these fixation methods. As evidenced by the radiographic healing of all fractures in our case series, it appears that bioabsorbable nails provide adequate biomechanical fixation. However, further biomechanical studies are needed to fully evaluate bioabsorbable nails.

Limitations

Limitations of this study include the small number of patients enrolled. Because of the rarity of this injury, however, we were confined by the volume of patients. Also, all patients were males. Furthermore, no objective laxity testing was performed on these patients because of lack of access to a knee arthrometer. An arthrometer may have provided further information on residual laxity in the knees not easily discernable from a Lachman or a pivot shift test. However, often, there is no significant correlation between objective knee laxity and subjective symptoms and function [12]. In addition, comparison of this group to one with suture fixation or screw fixation would have strengthened the study. Finally, we did not report on any type IV fractures in our case series. These fractures are comminuted and displaced and bioabsorbable nails are unlikely to provide adequate fixation. In addition, we did not have any cases of cartilaginous avulsions with minimal bony components. Bioabsorbable nails may not provide adequate fixation of cartilaginous avulsions. The optimal indication for using bioabsorbable nails for the fixation of tibial eminence fractures is likely in the setting of an avulsed osteochondral fragment without comminution and preserved attachment of the ACL.

Conclusion

Arthroscopic fixation of tibial eminence fractures with bioabsorbable nails yields satisfactory outcomes for this uncommon injury and obviates the need for future hardware removal.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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