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ORIGINAL ARTICLE

Arthroscopic treatment of avulsed tibial spine fractures using a transosseous sutures technique

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Severely displaced tibial spine fractures should be treated surgically to restore joint congruity and cruciate integrity with reduction and fixation through an arthrotomy or arthroscopic techniques. Arthroscopy is preferred as it allows for accurate diagnosis and treatment of associated injuries and reduction and fixation of all types of tibial spine fractures while reducing the morbidity associated with open techniques. We report the clinical and radiographical results of 11 cases treated with a technique of arthroscopic internal fixation with non-absorbable sutures, after an average follow-up of 16.3 months (range, 11 to 21 months). The clinical examination using the IKDC system revealed all patients to have a negative Lachman test and no quadriceps weakness except one patient with some laxity (hard end 1+ Lachman test). One patient had a minor extension deficit of approximately 5°. The other patients showed a full range of motion without extension loss. This technique is simple, reproducible and very useful in dealing with these fractures.

Keywords : arthroscopy ; tibial spine ; anterior cruciate ligament ; fixation ; suture.

INTRODUCTION

Tibial spine fractures are common injuries in children. The common mechanisms of injury are falls from bicycles, sports injuries and motor vehicle injuries. Hyperextension injuries of the knee are known to result in these fractures (*11*). This injury is an avulsion fracture and the original force takes place through the cruciate ligament. Hence, there is an associated weakness in the cruciate ligament (*14*). The bone fails before the ligaments and, hence, these fractures are common in children than in adults.

Tibial eminence is the intra-articular portion of the upper surface of the tibia. This consists of two spines, medial and lateral. The anterior cruciate ligament is attached to the medial spine. There is no structure attached to the lateral spine (*22*). Meyer and McKeever (*18*) classified the tibial spine fractures into three types : type 1 fracture is undisplaced ; type 2 is partially displaced or hinged ; and type 3 is completely displaced or inverted and impossible to reduce because of the transverse meniscal ligament preventing seating of the fragment.

Rockwood *et al* (*19*) suggested conservative treatment for type 1 and 2 fractures and operative treatment for type 3 fracture (Fig. 1). Zaricznyj (*23*) later described a type IV injury, which represents

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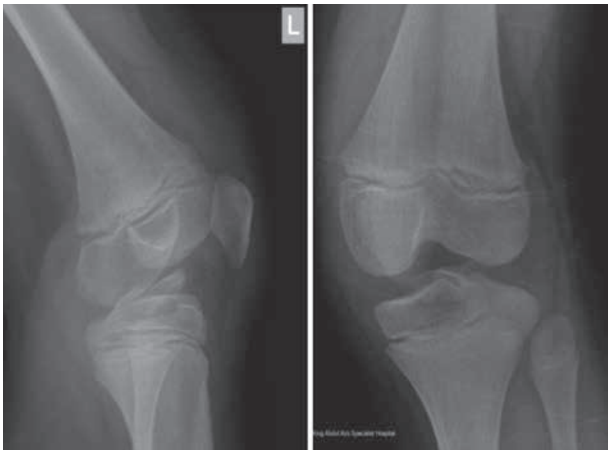

Fig. 1. — Lateral and anteroposterior radiographs of the knee showing a tibial spine avulsion fracture grade 3.

rotation and comminution of the fragments. Residual laxity and poor outcomes have been reported with closed treatment of displaced fractures. More recently, operative fixation has been advocated for type II, III, and IV injuries (9). Because this is an intra-articular fracture, there is an increasing tendency away from the use of metal hardware, which often requires a second procedure for removal. The advantages of using sutures instead especially in children have been described in the literature (3,9). The problem with suture techniques is the difficulty and the time consuming of passing sutures through the ACL avulsed stump and the tibial bone tunnels.

In this article, a technique is described that uses a spinal needle and thin cerclage wires to pass 2 sutures, one through the ACL substance and the second over the bone fragment through the same tibial tunnels, making the procedure fast and easy.

PATIENTS AND METHODS

Eleven cases of displaced tibial eminence fractures, treated with arthroscopic internal fixation from November 2008 to May 2012, were reviewed both clinically and radiographically after an average follow-up of 16.3 months (range, 11 to 21 months). The fractures occurred due to road traffic accidents (3 patients), falling down (5 patients) and sports injuries including football (3 patients). The fractures were classified using Meyer and McKeever's classification. All the patients had type III displaced fractures and were operated on as soon as possible. The mean age was 8 years (range, 6 to 11 years). There were 8 males and 3 females. There were no associated ligament injuries. However, there was 1 case with an oblique tear of the medial meniscus which was treated with partial meniscectomy. Evaluation was done using IKDC system.

OPERATIVE TECHNIQUE

Under general or regional anesthesia and pneumatic tourniquet the limb is fixed in a thigh support with the leg hanging free. Through standard arthroscopy portals (anterolateral and anteromedial) concomitant injuries are visualized and treated as needed and the tibial spine fragment is probed to determine the amount of displacement, comminution, and soft tissue involvement. Often the avulsed fragment is larger than that suggested by the radiograph due to the cartilaginous component. The medial meniscus, lateral meniscus, and intermeniscal ligament are examined and probed to determine their relationship to the fracture fragments. The ACL should be examined for ecchymosis and attenuation. A 3.5-mm motorized shaver is used to debride haematoma and loose fragments from the fracture base. Sometimes the medial meniscus or intermeniscal ligament is incarcerated in the fracture and it is released with a probe. The fracture site is deepened for 2 mm with a burr to compensate for any plastic deformation with stretching of the ligament (2). The fracture is then reduced (with a probe or blunt trocar) and provisionally held with a percutaneous 1.5 mm Kirschner wire placed with the knee at 90 degrees of flexion through an accessory anteromedial portal. The direction of the K-wire is oblique downwards in an anteroposterior plane (Fig. 2).

An ACL tibial guide is placed through the patellar central portal and used to maintain reduction of the tibial spine fragment (Fig. 4). It is important to place the guide at a steep angle (60 degrees or more) so the drill hole comes out in the anterior part of avulsed bone and ACL fibers. This allows for easier retrieval of sutures and wires. Once appropriate intraarticular position of the guide is established, a 1-cm incision is made over the proximal anteromedial tibia. The bullet of the ACL tibial guide is se-

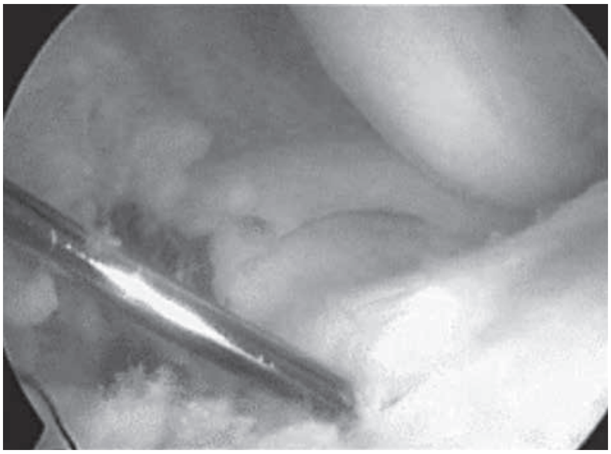

Fig. 2. — Provisional fixation with a Kirschner wire (Lt. knee, viewing from anterolateral portal).

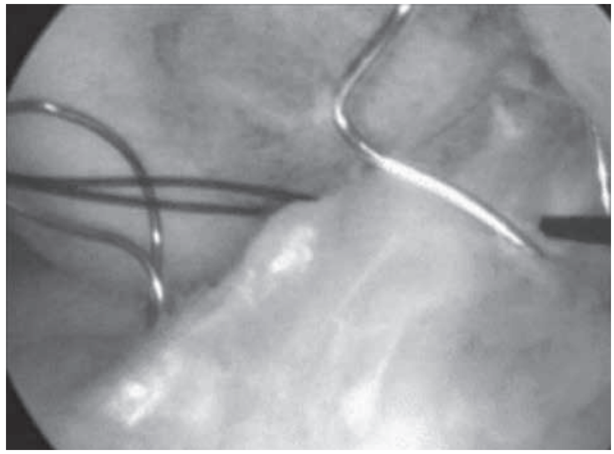

Fig. 3. — The loop end of the suture is then pulled out with a hook from the accessory anteromedial portal and acting as a relay suture, is followed by the first No. 2 polyfilament non-absorbable suture.

cured at the anterior tibial cortex, then a 2.4 mm passing pin is drilled to penetrate the fracture on one side of the ACL. With the drill guide still in place, a thin 26- or 30-gauge wire is bent in half and passed through the guide and into the knee. The tibial guide is removed, and the wire is retrieved out the accessory anteromedial portal with a grasper. This step is repeated on the other side of the ACL from the same incision while keeping a bone bridge of at least 1 cm long on the anterior tibial cortex.

In most fractures (most importantly, in comminuted fractures), the second suture is passed through the ACL substance. A spinal needle loaded with No. 1 monofilament suture (Prolene, Ethicon, Norwood, MA) is passed from the skin lateral to anterolateral portal through first the widened lateral wire loop, then ACL substance and finally the widened medial wire loop. The loop end of the suture is then pulled out with a hook from the accessory anteromedial portal (Fig. 3). Using a monofilament suture first is easier in manipulation intra-articularly and it glides smoothly inside the needle. It will act as a relay suture to pass one end of the first No. 2 polyfilament non-absorbable suture (Orthocord, Depuy-Mitek, Norwood, MA) through both wire loops and the ACL substance and out from the skin. The second No. 2 non-absorbable polyfilament suture is passed through the loops of the two wires outside the knee which are then pulled out the anteromedial tibia, followed by the ends of two sutures. Passing the second suture through the wire loops outside the knee is easier and saves an additional step of using the spinal needle with a relay suture as in the first suture. Two horizontal mattress sutures are established and completed, one outside the ligament and the other inside its substance.

Because a sliding horizontal suture loop has been established, sliding knot-tying techniques are used to assure the knot is tied flush on the anterior tibial cortex. This technique is especially useful in larger individuals with abundant subcutaneous tissue, where standard knot tying may be more cumbersome. Once the fragments have been stabilized, the knee is again arthroscoped, and direct visualization of the fracture reduction and stability are evaluated by probing and placing the knee through 0 to 90° of range of motion. Lachman testing is also performed under direct arthroscopic visualization. The portals and incisions are closed with 3-0 nylon sutures.

Post-operatively, the knee is kept in a knee immobilizer in extension for 4-6 weeks after radiographical checking of reduction (Fig. 4). The patient is allowed to mobilize on crutches with partial weight bearing for the first 2-4 weeks. Initially range of motion exercises and active hamstring flexion exercises are started in a prone position. Straight leg raising and quadriceps setting are started as well. Active open chain quadriceps

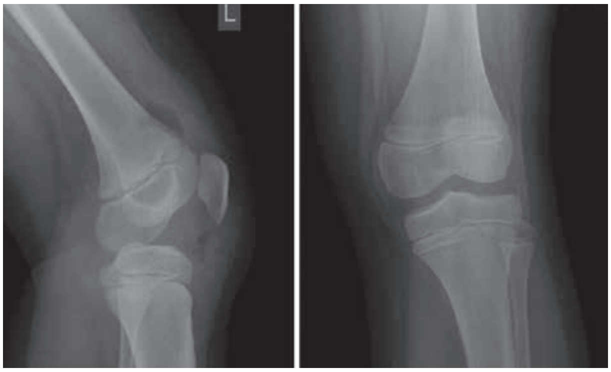

Fig. 4. — Post-operative radiographs of the same patient showing the fracture well reduced anatomically.

contractions are not allowed for 6 weeks. Full weight bearing without crutches the knee in full extension as tolerated is allowed at 4 to 6 weeks and the knee immobilizer is discontinued. Stationary biking and swimming are allowed at 6 to 8 weeks. Sport-specific exercises, including start/stop/pivot shift type of activity, are allowed at 12 weeks. It is not uncommon for patients to exhibit quadriceps atrophy, weakness, and lack of proprioception until 6 to 9 months postoperatively. At 6 months patients are allowed to go back to unlimited activity and return to full function, similar to the anterior cruciate reconstructed knee.

RESULTS

Clinical examination revealed all 11 patients to have no quadriceps weakness. All had a negative Lachman test, except one patient with a 1+ hard end point Lachman. One patient had some minor extension loss of approximately 5 degrees. The other patients showed a full range of motion. Post-operative radiographs showed well reduced tibial spine fragment in all patients. All patients had resumed their full activity by 6-9 months. IKDC final evaluation was grade A in 9 cases and grade B in 2 cases.

DISCUSSION

Avulsion fractures of the tibial spine are common in children. This is because of the earlier failure of bone as compared to ligament in this age group (*11*). Fractures of the tibial spine can be treated either conservatively or operatively. The decision depends upon the amount of displacement (*7*). There is evidence that even in the absence of displacement of the fracture, ligament instability suggests a possible displacement and, hence, the necessity for operative fixation (*3*). Also, the goal of treatment should be restoration of the joint congruity (*22*). The surgical options are either open reduction and internal fixation (*7*) or arthroscopic reduction and fixation. Arthroscopic method has obvious advantages. It causes less morbidity and allows the surgeon to evaluate the joint for associated injuries (*8*). It has been shown that fractures anatomically reduced by closed manipulation have a tendency to displace with time (*15*). For this reason, reduction and fixation of all type II, III, and IV fractures is recommended.

The most common fixation methods include cannulated screw, K-wires, non-absorbable sutures or recently anchors (*13*). The advantages of suture fixation are no prominent hardware, no potential damage to an open physis with minimal tunnels diameter, rigid fixation with early range of motion exercises and better fixation in comminuted fractures. Fixation with a cannulated screw can easily crush bony bone fragments and cut ligaments, increases the likelihood of damaging the open physis and requires a second procedure for later removal (*19*). Hunter and Willis (*9*) reported a 44% reoperation rate in patients treated with cannulated screws. Bong *et al* (*4*) compared the biomechanics of suture and screw fixation of tibial spine fractures in a cadaver model and determined that suture fixation was mechanically superior to cannulated screw fixation. The choice of using anchors for fixation may look interesting but it is tedious and expensive with pullout strength not better than sutures (*10,13,20*).

Children and adolescents uniformly do very well after fixation of tibial spine fractures (*2,17*). The main complications are laxity, restricted motion with extension lag, and persistent pain (*12*). Various studies have shown, however, that long term function is more closely related to restriction of motion and pain than it is to laxity. Laxity does not seem to correlate with poor outcomes. Muscular control has also been associated with reduction in function after these injuries, and it is imperative to institute an aggressive postoperative rehabilitation program aimed to reeducate neuromuscular control of the limb (*1*). Loss of extension secondary to scarring in the anterior compartment of the knee can occur. Should the loss exceed more than 5-10°, arthroscopic debridement and notch-plasty is effective for regaining motion. Lack of full extension can also occur from displacement of a fixed tibial spine or from a malunion (*15*).

The weak link in the fixation construct described is the suture used. The suture characteristics important for a stable construct include strength and knot security. Gerber *et al* (*6*) found that nonabsorbable suture is stronger and stiffer than absorbable suture to withstand tensile stresses on the ligament and allows secured early range of motion exercises, though it is used by some surgeons with good results (*16,21*). Elkousy *et al* (*5*) determined that a sliding knot followed by 3 half hitches on alternating posts improves knot security to withstand in vivo loads. The fixation described in this technique uses a horizontal mattress, sliding, No. 2 braided nonabsorbable suture. The sliding configuration allows for easy knot tying. Using cerclage wires and spinal needle to pass the sutures makes this technique simple and easy without the need for special instruments.

The limitation of this study is the fact that it has been used in relatively small number of patients.

CONCLUSION

The goal of the treatment should be anatomic reduction to restore joint congruity. This technique of arthroscopic fixation with transosseous sutures is very useful in treating these fractures. Approaching these injuries arthroscopically allows for complete inspection of the joint and dealing with associated injuries, early mobilization, fast rehabilitation, and decreased hospital stay. Suture fixation has the advantages of being more versatile and biomechanically superior to screw fixation and has the ability to fix not only isolated large but also small and comminuted fractures and to incorporate the ACL into the fixation structure. Also, there is minimal risk of damage to the epiphyseal plate in children, and there is no need for hardware removal. Furthermore, sutures allow for stable fixation and aggressive early rehabilitation. Arthroscopic suture fixation uniformly leads to excellent outcomes.

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