Evaluation of Results of Arthroscopic Fixation of Anterior Cruciate Ligament Tibial Avulsion Fractures with the Suture Pull-out Technique

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Abstract

Background: Tibial anterior cruciate ligament (ACL) avulsion fractures are a common injury in children and adolescents. Operative treatment is indicated for types 2, 3, and 4 fractures. Arthroscopic fixation is the preferred method, and numerous fixation options are described. The purpose of this study is to evaluate the results of a new technique of arthroscopic fixation.

Methods: A retrospective study was done involving six patients having displaced ACL tibial avulsion fractures. The arthroscopic suture “bridge” pull-out technique was used to fix these fractures. Patient symptoms such as knee pain, locking, clicking, sensation of giving way and clinical signs such as tenderness, range of motion, McMurray’s test, stability test, and Lysholm knee scores were evaluated pre-operatively and post-operatively at 3 months and 6 months. Patient satisfaction was noted at latest follow-up.

Results: One patient had type 2, 4 patients had type 3, and 1 patient had type 4 tibial ACL avulsion fractures. All the fractures united, and all patients achieved full knee range of motion by 2.5-month post-operative. The clinical symptoms and signs improved post-operatively. The mean Lysholm knee score at 3-month follow-up was 91.4 and at 6-month follow-up were 98.2. At the latest follow up, all the patients were satisfied with their knee function. Conclusions: The arthroscopic suture “bridge” pull-out technique is an effective method for fixation of ACL tibial avulsion fractures with respect to knee stability, range of motion, and resumption of pre-injury activity level.

Keywords: Knee arthroscopy, suture pull out, bridge, anterior cruciate ligament tibial avulsion.

Introduction

Tibial anterior cruciate ligament (ACL) avulsion fractures are a common injury in children and adolescents. In adults, they account for 1–5% of ACL injuries [1]. They are caused by a hyper extension injury of the knee or by a direct force over the distal femur with the knee in flexion. Meyers and McKeever have classified these injuries depending on the amount of displacement of the ACL tibial fragment as follows: Type 1 – minimal or undisplaced fracture fragment; type 2 – elevation of only the anterior half of the fragment; type 3 – complete displacement of the fragment; and type 4 (modified by Zaricznyj) – comminution of the displaced fragmented.

Non-operative treatment in the form of immobilization is indicated for type 1 fractures. Non-operative treatment for type 2 to type 4 fractures in the form of manipulation in extension fails to achieve reduction of the fragment as the fracture lies in the intercondylar notch and not between the articulating surface of the tibia and femur [2].

Operative treatment is indicated for types 2, 3, and 4 fractures as these displaced fractures can develop non-union or malunion resulting in knee instability and anterior impingement causing loss of knee extension [3]. Surgical techniques include open or arthroscopic reduction and internal fixation. Open reduction and internal fixation involve arthrotomy, soft-tissue dissection, and prolonged immobilization resulting in high chance of knee stiffness. The arthroscopic technique is the preferred treatment modality as it allows magnified vision, accurate reduction, minimal soft-tissue dissection, stable fixation, and management of associated intraarticular pathologies. The fixation options include wires, staples, screw, and sutures. The advantage of using sutures is that they provide very stable and rigid fixation and do not need removal.

The suture fixation techniques described in literature utilize two tunnels drilled on either side of the tibial ACL fragment. The sutures are then passed around the ACL and passed through the tunnels followed by tying over the anteromedial (AM) tibial bone bridge. This suture construct can result in excessive ACL tension, uneven compression of the bony fragment and elevation of the anterior part of the fractured...
fragment. The overtensioning of the ACL can result in restricted knee range post-operatively, and the anterior elevation of the fragment can cause impingement in extension.

With increasing knowledge of anatomical ACL reconstruction, recreating the ACL footprint anatomically without overtensioning the ACL comes to attention. The purpose of this study is to evaluate the results of repairs of ACL tibial bony avulsion fractures using the suture “bridge” pull-out technique.

Methods
This was a retrospective study conducted in the department of orthopedics at a tertiary level hospital. Patients having displaced ACL tibial avulsion fractures as diagnosed on plain radiography were included in this study. Six patients were included in this study.

Pre-operative data recording included age, sex, side, mechanism of injury, duration since injury and complains with respect to pain, locking, clicking, sensation of giving away, and swelling. Clinical examination included tenderness, range of motion, McMurray’s test, and tests for instability. Lysholm knee score was recorded pre-operatively. Radiological investigations included X-rays and magnetic resonance imaging (MRI) of the knee. Patient is placed supine with affected leg secured on a leg holder. Standard arthroscopic setup and instruments are required for the surgery. Few instruments, which are specific to suture fixation technique, are 90° suture lasso with wire loop, epidural needle no.16 and suture retriever. Although image intensifier is not usually required, it should be kept ready so that whenever it is required intraoperatively it can be used.

After giving IV antibiotics, leg is exsanguinated and tourniquet is inflated. Standard AM and anterolateral portals are made, adequate lavage is given to drain hematoma and clear the vision. The organized hematoma at the fracture site is removed with aggressive shaver blade, and fat pad is removed if required. In all cases, calf should be palpated at regular interval of time to assess compartment pressure.

Diagnostic arthroscopy is carried out to assess additional injuries such as meniscal injury, chondral injury, or other ligament tears. Fracture crater is adequately cleaned; additional cancellous bone can be curetted to achieve better reduction. After achieving temporary reduction of fragment with 2-mm Kirschner wire from superomedial portal assess
the reduction. Entrapped soft tissue or intermeniscal ligament is released if they are hindering the reduction. Two drill holes are made with 2.7 mm guidewire with the help of tibial ACL jig medial and lateral to ACL and exiting out on medial tibial cortex. With the scope in lateral portal and 90° suture lasso through medial portal, a bite is taken in posterior half of ACL substance as close to fragment as possible and retrieve the cable loop through accessory lateral portal or by slightly enlarging lateral portal. Pass a fiber wire no. 2 through the loop and take it out through medial portal. This step is repeated by taking a suture bite through anterior half of substance of ACL. Epidural or spinal needle no.16 is passed through medial tibial drill hole. Once epidural needle is seen in joint no. 1, prolene loop is passed through the needle for suture shuttle. Prolene loop is retrieved through the medial portal. Both the fiber wire threads are passed through the prolene loop outside the joint, and then, prolene is pulled after holding lateral end of fiber wire with hemostat. Both fiber wire medial sutures will be shuttled through the medial tibial tunnel. This step is repeated for lateral sutures also and retrieved through lateral tibial tunnel. Both ends of fiber wire are held under traction and reduction is assessed. In full extension, roof impingement is checked. If there is no obstruction to full extension sutures are tied independently over the bone bridge or if bone bridge is inadequate sutures can be tied over endobutton or suture wheel in extension. In skeletally immature individuals, tibial tunnels are made only through epiphysis. Entrance of the drill tip is confirmed under image intensifier before making tibial tunnels. Growth plate is not damaged with this method of fixation.

Post-operatively, the knee was placed in a long knee brace, and ankle pump exercise, static quadriceps sets, and active straight leg raises were started immediately after surgery. Active knee bending was started as per pain relief, usually from the 2nd post-operative day. The patients were mobilized non-weight bearing till 6 weeks post-operatively. Bedside knee bends and prone knee bends are started after 4 weeks. Full weight bearing with long knee brace was allowed after 6 weeks. The long knee brace was discontinued after 2 months. The patient is allowed running, jumping, and sporting activities after 6 months. Post-operative data recording was done on the 3rd and 6th month follow-up as follows: Patient complaints of pain, locking, clicking, sensation of giving way, and swelling and clinical examination for tenderness, range of motion, McMurray’s test, and tests for instability and Lysholm knee score. At latest follow up, patient satisfaction with respect to knee pain, range of motion, stability, and return to previous activity level was noted.

Results

Of the six patients included in the study, all were males having a mean age of 27.2 years (range: 18–35 years). The left knee was involved in 2 cases and the right knee in 4 cases. All the patients had a twisting knee injury following which their knee complains started. Four patients had a road traffic accident, two had a twisting injury due to a, and five patients presented acutely at an average time of 8 days (range: 5–24 days) from injury. One patient had a delayed presentation at 8-week post-injury. All patients presented with chief complaints of knee pain. The patient who presented late complained of locking, clicking, and sensation of giving way while walking. One patient who presented acutely complained of clicking from the knee. All the patients who presented acutely had knee swellings. All the patients had anterior knee joint line tenderness. The patient with delayed presentation had full knee range of motion. The mean knee range of motion of the patients who presented acutely was 70° (range: 60–120°). McMurray’s test was positive in only one patient. This test was not performed for the patients who presented acutely. Anterior drawer test was performed in 1 patient and was positive (grade 3) in both. Lachman’s test was performed in all the patients and was positive in all (grade 3: n = 4, grade 2: n = 2). The pre-operative Lysholm knee score was not calculated for the patients with acute presentation. The pre-operative Lysholm knee score for the patient who had a delayed presentation was 44. On X-ray of the knee, 1 patient had type 2, 4 patients had type 3, and 1 patient had type 4 tibial ACL avulsion fractures. MRI of all patients showed an intact ACL with one patient having a medial meniscus tear. Fig. 1 shows pre-operative X-ray of the patient with tibial spine avulsion 5 days old. Fig. 2 shows MRI of the same patient showing avulsion in coronal and sagittal plane. Diagnostic arthroscopy confirmed the findings of tibial ACL avulsion fracture with an intact ACL in all the patients. None of the patients had any chondral lesions. Fig. 3 shows intraoperative avulsed fragment on arthroscopy. Fig. 4 shows the arthroscopic fixation by pull through suture technique. One patient had a medial meniscus tear. Fig. 5 shows post-operative X-ray of patient. All the fractures united and all patients achieved full knee range of motion by 2.5 months post-operatively. Fig. 6 shows range of movement after 6 months. At
3 months follow-up, 1 patient complained of pain in the knee. One patient had knee effusions in post-operative period which settled down with exercise restriction and anti-inflammatory medications. None of them complained of sensation of giving way. McMurray’s test, anterior drawer test, and Lachman’s test were negative in all the patients. The 3-month follow-up mean Lysholm score was 91.4.

At 6-month follow-up, no patient had knee pain. None of the patients had any knee locking or sensation of giving way. All of them had full knee range of motion. Knee joint line tenderness, McMurray’s test, anterior drawer, and Lachman’s test were negative for all the patients. At 6-month follow-up, mean Lysholm score was 98.2. At latest follow-up, all the patients were satisfied with their knee function with respect to pain, range of motion, and stability and had resumed their previous level of activities.

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Discussion
Displaced ACL tibial avulsion fractures (Meyers and McKeever types 2, 3, and 4) need operative intervention as immobilization fails to obtain reduction of the fracture fragment into its crater as the fracture is in the non-articular part of the knee (intercondylar notch) and not in the tibiofemoral articulation [4]. Malunited or non-united ACL tibial avulsion fractures can cause anterior instability and restricted knee range of motion [5,6]. Anterior instability occurs because the ACL remains lax due to no tibial bony attachment. Restricted knee range and occurs due to anterior impingement of the bony fragment in terminal extension [4]. One patient in this study who had a delayed presentation complained of instability in the form of sensation of giving way and had Lachman’s test positive on examination.

Arthroscopic reduction and internal fixation are the preferred treatment option for displaced ACL tibial avulsion fractures. The arthroscopic techniques have the advantage of being minimally invasive resulting in minimal scarring of the fat pad and the retro patellar tendon space, thus reducing the chances of post-operative stiffness. In the present study, all the patients achieved full knee range of motion by ½ months post-operatively. The arthroscopic techniques also provide magnified and illuminated vision of the intercondylar notch thus enabling accurate reduction and secure fixation. It also provides an opportunity to identify and treat any other associated intraarticular pathology. In the present study, one out of the six patients had associated meniscal tears which was identified and addressed arthroscopically in the same surgical setting.

A variety of fixation techniques has been used to fix these fractures arthroscopically, some of them being screw (antegrade, retrograde), K-wires, wire loops, staples, suture anchors, and sutures [2,3,7,8]. Most of the ACL tibial avulsion fractures are just a sliver of bone being held together by the fibers of the ACL. The fracture bed is of poor bone quality due to the fracture. Invariably comminution is noted arthroscopically even in types 2 and 3 fractures. Although Tsukada et al. reported that antegrade screw fixation was more effective to obtain initial rigid fixation than pull-out suture fixation for ACL avulsion fractures, we believe that this technique requires drilling of the bony fragment which can cause its comminution [4]. Veselko and Senekovic reported fixing thirty-two fractures with cannulated screws and washers. Fixing comminuted fracture with screw and washer was technically impossible [7]. Yip et al. have mentioned that the bony components in avulsion injuries are very small and cancellous, and thus, the purchase of screws or wires is unreliable [9]. There is risk of screws backing out into the joint, posterior neurovascular injury, extension block by the screw head or washer during the post-operative period, and need for hardware removal after 8–10 weeks [4,8]. Use of single or multiple staples has the same disadvantage as that of screws, and they are placed in the fractured bone bed which has poor hold for implants. Sundararajan et al. reported backing out of a staple in 1 out of 22 patients in their study [2]. They advocated staple removal in case of radiological loosening or back out. The use of multiple suture anchors does give multiple points of fixation, but there is a possibility of pullout of the anchors [3]. K-wires have insecure fixation, and there is possibility of migration. All metal implants can affect future knee imaging due to metal artifacts and can interfere with any other future knee surgery.

The use of pull through sutures to fix the ACL tibial avulsion fracture has many advantages compared to the previously discussed metal fixation options. Huang et al. mentioned that suture fixation techniques do not require further surgery for implant removal [3]. The sutures hold the fragment at the bone–ligament interface and thus have very good hold even in comminuted fractures [6]. The use of sutures does not need drilling of the fragment and thus can be used even in comminuted fractures and gives secure fixation as they are tied over the AM tibial cortical bony bridge. Multiple sutures can
be used for fixation of the bony fragments. Sutures do not cause any artifact in future imaging nor interfere with any future knee surgery [3]. There is no elevation of the anterior part of the fragment, and hence, there is no impingement in extension. There is no anterior translation of the ACL tibial fragment and no overtensioning of the ACL, and hence, there is no restriction in the knee range of motion post-operatively.

**Limitation of the study**
The drawbacks of the present study are the small number of patients.

**Conclusion**
The present study was a small attempt to study the clinical results of fixation of ACL tibial avulsion fractures using a new technique. The arthroscopic suture pull-out technique is an effective method for fixation of ACL tibial avulsion fractures with respect to knee stability, range of motion, and resumption of pre-injury activity level.

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