Technical Note

Arthroscopic Fixation of Anterior Cruciate Ligament Avulsion Fracture Using FiberWire Suture With Suture Disc

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Abstract: Controversy still exists regarding how to reduce and fix a displaced tibial avulsion fracture. Open reduction and internal fixation may lead to morbidity due to soft-tissue injury and arthrotomy. As a result, arthroscopic techniques are increasing in popularity. In the literature, sutures, K wires, and screws are suggested to be used as the fixation devices. Screws cannot be used in small or comminuted fractures, whereas K wires and sutures may not provide strong stability. Recently, with the advent of ultrahigh molecular weight polyethylene sutures like FiberWire, it has become possible to use it as the fixation device in even comminuted avulsion fractures with acceptable reduction stability. In this paper, we describe a simple arthroscopic technique using a FiberWire to manage the displaced tibial eminence avulsion fracture.

Introduction (With Video Illustration)

Anterior cruciate ligament (ACL) avulsion fracture (Fig 1), which is also called tibial spine fracture, is not common. The incidence of isolated ACL avulsion fracture is estimated at 3 per 100,000 annually.[1,2] However, due to increased athletic activity in children and ever-increasing high-energy motor vehicle accidents in adults, its incidence is rising both in children and adults. It mostly is seen in those aged 8 to 14 years.[3,4] Two to five percent of post-traumatic knee hemarthrosis and 14% of ACL injury in children are demonstrated to be due to ACL avulsion fractures.

It is a good practice to consider operative treatment in cases having displaced (>2 mm) type 2 or type 3 to 4 according to the modified Meyers and McKeever classification,[5,6] as operative treatment has a lower rate of postoperative remaining anterior knee laxity and is associated with a decreased need to further reconstruct the patient's ACL in the future.[2,7,8] The surgical method of choice, however, is still subject to debate. Arthroscopic reduction and fixation have become popular due to limited skin incision and soft-tissue injury. A wide variety of devices, including screw,[9,10] staple,[11] tension wiring,[12] K wire,[13,14] suspensory fixation,[15] suture,[16-21] and anchor sutures[2,22,23] have been used to fix the ACL avulsion fracture during arthroscopy. In this article, we describe our technique for arthroscopic fixation of the ACL avulsion fracture (Video 1) and further delineate its pros and cons for managing ACL avulsion fracture.

Technique

After spinal anesthesia, the patient is placed in a supine position and a tourniquet is fitted in the proximal thigh. As with conventional ACL reconstruction surgery, the knee and calf hang from the edge of the surgical bed at 90° with a leg holder in a way that knee movements are not restricted.

Cefazolin (2 g, intravenous) and tranexamic acid (1 g, intravenous) are injected. After surgical skin prep and draping, patella, patellar tendon, anterolateral, and anteromedial portals are identified and marked. Sterile plastic sticking is placed on the surgical site and the tourniquet (with 250-300 mm Hg) is activated.

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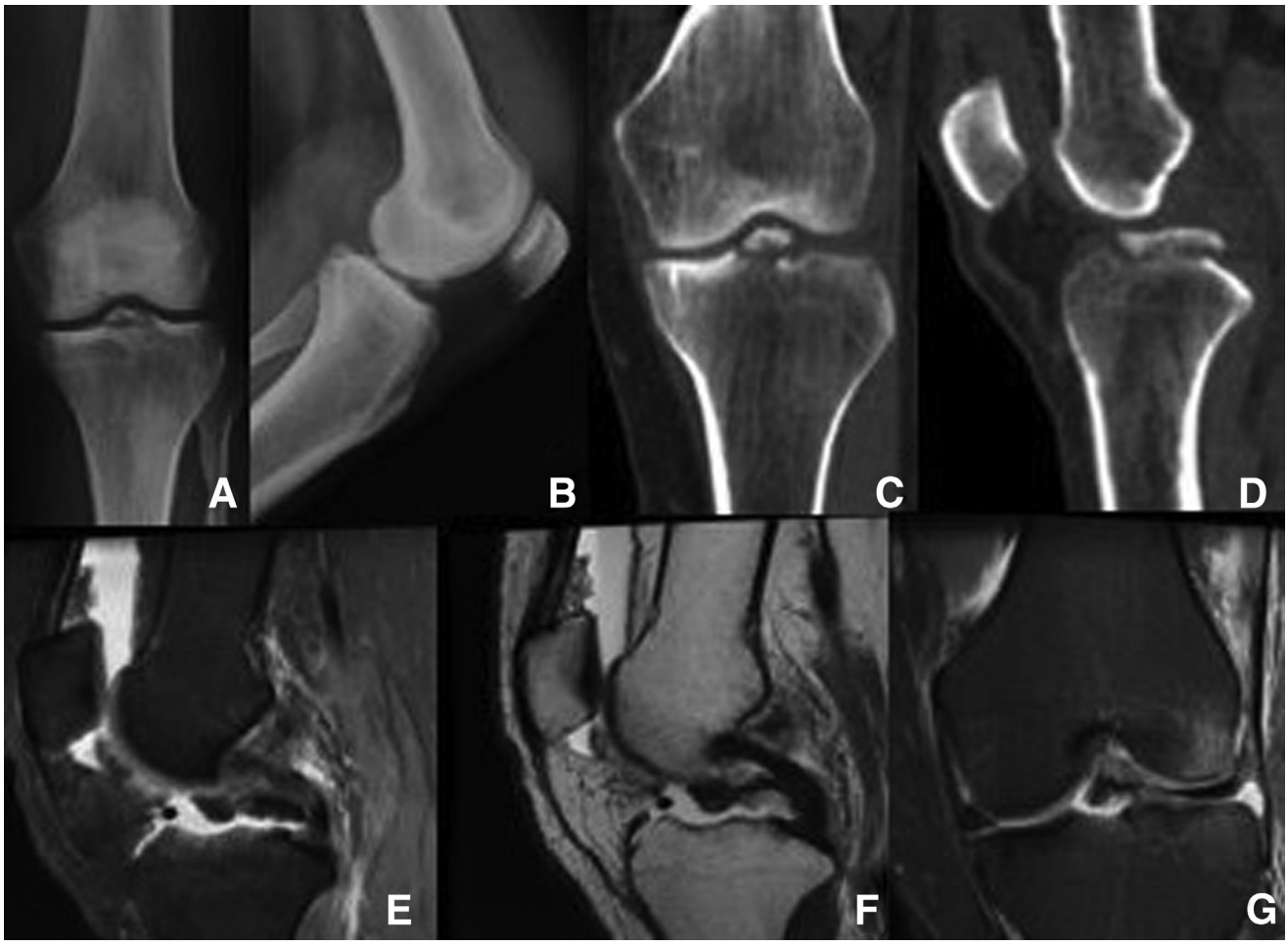

Fig 1. The plain knee radiographs (A, B) and computed tomography scan (C, D) of a patient with ACL avulsion fracture type 3 according to Meyers and Mckeever.[5] On magnetic resonance imaging, the patient had no evidence of ligamentous or meniscus injury (E-G). (ACL, anterior cruciate ligament.)

The standard arthroscopic system with an anteromedial working portal and anterolateral visual portal is applied. Any hematoma at the fracture site is evacuated, and interposed tissues obstructing the fragment reduction (e.g., intermeniscal ligament) are removed. Diagnostic arthroscopy is conducted to rule out any accompanying lesion in the knee joint (i.e., ACL, meniscus, etc.). The crater of the fracture fragment is debrided by arthroscopic shaver and is made ready for reduction.

A cannula is inserted at the anteromedial portal. Two separate FiberWire sutures (Arthrex, Naples, FL) are selected. By means of Lasso (Arthrex) with wire loop, sutures are passed through the ACL near the fracture site (one through the medial half and the other through the lateral half of the ligament) (Fig 2). By using arthroscopic sliding knot, a FiberWire suture is tied over each border (lateral/medial) of the ACL (Figs 3 and 4). A longitudinal incision is made on the anteromedial tibia 4 cm below the joint line. Two 2.7-mm tibial tunnels are made by 2 K wires inserted through an ACL jig (ACUFEX ACL tibial guide; Smith & Nephew, Andover, MA) from the anteromedial side of the tibia to the tibial plateau (their proximal endings at the lateral and medial side of the fractured fragment). The distal points of the tunnels are tuned to be 1 cm apart from each other (Fig 5). Then the pins are removed. A suture retriever (Arthrex) is applied to pull out the 2 ends of the medial suture through the medial tunnel and the lateral suture through the lateral tibial tunnel. Following reduction of the fracture with a probe, the 2 FiberWires are tied together over a suture disc while the knee is flexed 20°. Finally, fixation stability is checked during the knee range of motion, the joint is irrigated, and the surgical wound is closed.

Postoperatively, the knee is immobilized by a hinge knee brace locked in full extension. Knee range of motion gradually is increased to 120° of flexion within 6 weeks. In the first 2 weeks, weight-bearing is not allowed. After that period, partial weight-bearing is initiated. After 8 weeks, the brace is discontinued and the patient is allowed to bear weight fully.

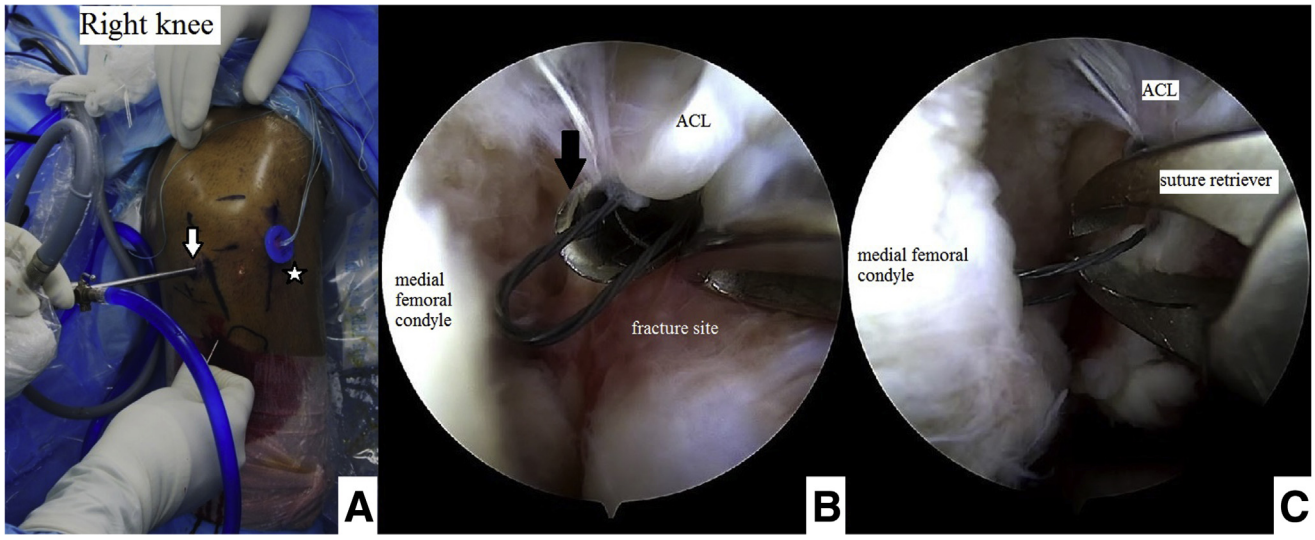

Fig 2. The patient is in a supine position. The injured knee (right knee) is hung with a leg holder while the joint is flexed at 90° (A). The visual anterolateral (white arrow) and working anteromedial portals are applied. A cannula (white star) is used to facilitate suture passage through the anteromedial portal. Suture lasso loop (black arrow) is inserted through the anteromedial portal into the joint and is passed through the ACL (B). Then, the loop is grasped and retrieved via suture retriever through the anteromedial portal (C). (ACL, anterior cruciate ligament.)

The advantages/disadvantages and the pearls/pitfalls of our technique are detailed in Tables 1 and 2, respectively.

Discussion

Since the description of ACL avulsion fracture in 1875 by Poncet,[8] different surgical management options for ACL avulsion have been introduced. McLennan in the year 1982 revealed that arthroscopic fixation is a viable option with less damage to the soft tissue compared with the conventional open fixation.[14] However, debate still continues over which fixation device to use during arthroscopy. The ACL insertion zone on the tibial eminence is relatively small (18 × 19 mm).[24] Therefore, fixation of the avulsed fragment through arthroscopic portals would be technically demanding. Baxter and Willey[25] followed 45 patients for 3 to 10 years and found that all cases had a degree of extension lag postoperatively and anterior laxity remained in one-half of their patients after the operation.

Screws have the theoretical advantage of strongest purchase for fracture fixation. However, as the proximal tibia is a cancellous bone, the strength of fixation may not be as rigid as expected. An inserted screw may tear the ACL or create small avulsed bony fragments. In addition, an applied screw has the risk of future impingement during knee extension or neurovascular compression. Lastly, a second operation would be inevitable to remove the device after fracture healing.

K wires are able to fix smaller fracture fragments. Also, using a K wire is associated with less injury to the proximal tibial physis and is safer to use in adolescents.

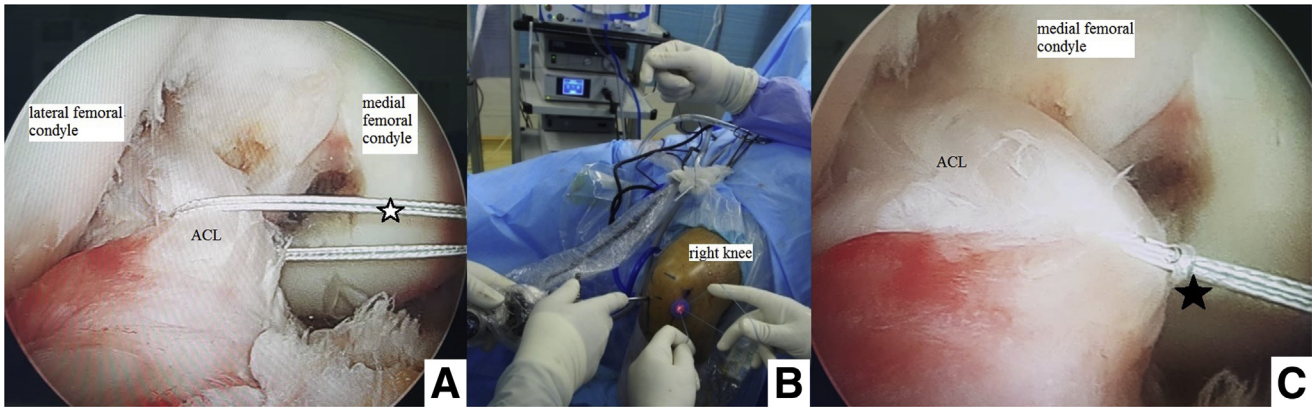

Fig 3. The FiberWire suture (white star) passed through the ACL (A) is tied on its lateral border by forming an arthroscopic sliding knot (black star) (B, C). (ACL, anterior cruciate ligament.)

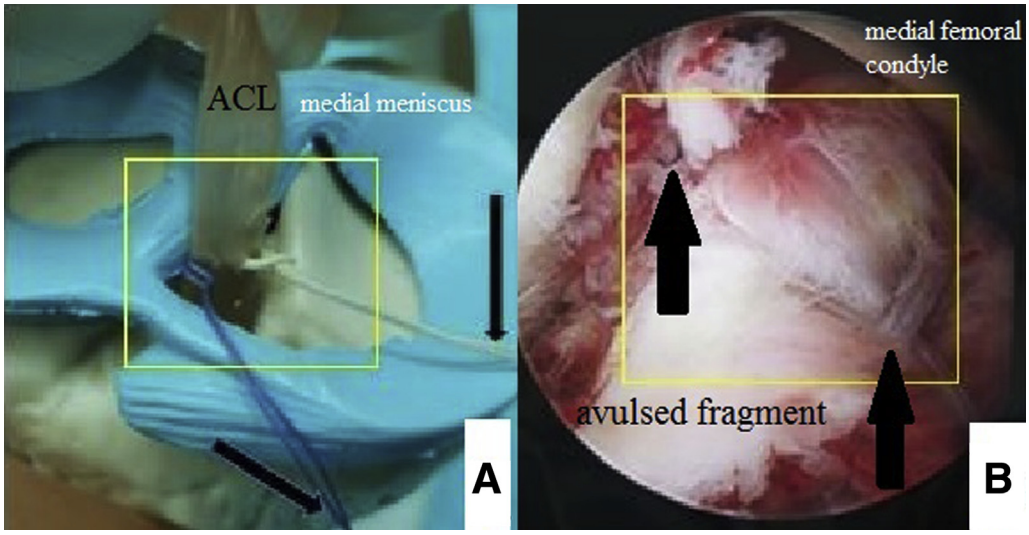

Fig 4. As the medical moulage (A) and the arthroscopic photo (B) illustrate, an arthroscopic sliding knot is used to tie a separate FiberWire suture (black arrows) over each border of the ACL (lateral and medial border). (ACL, anterior cruciate ligament.)

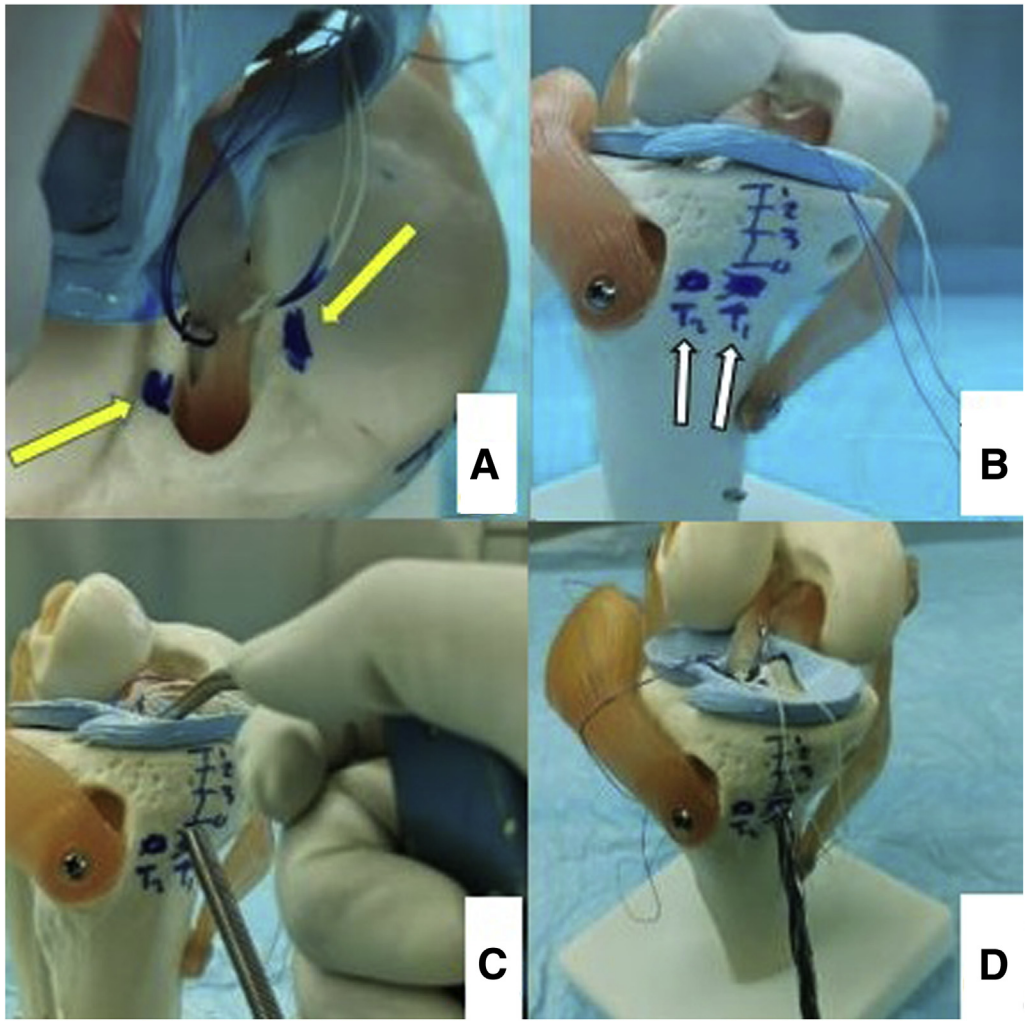

Fig 5. As our moulage model represents, 2 tunnels in the anteromedial side of the tibia are drilled in a way that their proximal endings are set at the medial and lateral sides of the fractured fragment (yellow arrows) (A) and their distal ends are just medial to the tibial tubercle 4 cm below the joint line (white arrows) (B). The distal ends of the 2 tunnels should be 1 cm apart from each other (C, D).

Table 1. Pearls and Pitfalls of ACL Avulsion Fixation Using FiberWire and Suture Disc

Pearls
The knee hangs from the edge of the bed with a leg holder, which improves the surgeon's operative view.
Irrigation and debridement of the fracture site decrease the risk of fracture non-union.
Removing any loose bodies is necessary to decrease the risk of knee motion limitation.
Using a cannula facilitates the passage of sutures and arthroscopic instruments through the anteromedial portal.
Passing the suture through the ACL tissue just above its insertion site eliminates the risk of further fragment comminution and can be applied even for fixation of the small fragment
Using 2 fixation points (at medial/lateral half of the ACL) enables the surgeon to better control and maintain reduction of the avulsed fragment.
Before knotting on the suture disc, the reduction should be checked while pulling the 2 FiberWire sutures. Also, the surgeon assesses for any possible impingement during the knee extension.
The suture disc eliminates the cutting impact of FiberWire on the bone bridge.
Pitfalls
To prevent any anterior knee laxity, the correct reduction of the avulsed fragment and the adequate amount of the ACL tension should be assured before final tying of the sutures.
To prevent a possible extension gap, knotting sutures on the suture disc should be done when the knee is flexed to 20°.
A thin suture bite may result in FiberWire cutting through the ACL during the postoperative rehabilitation.

ACL, anterior cruciate ligament.

In contrast, the rigidity of their fixation is limited. As a result, the surgeon has to immobilize the patient longer, exacerbating the postoperative extension lag and range of motion limitation.

Suture and suture anchors,[2] contrary to the other devices, can be used as a fixation method for ACL avulsion independent of the fragment size or the patient's age. They also eliminate any need for future device removal. Previous studies demonstrated that the suture anchor or high-strength suture (e.g., FiberWire) application can have a stiffness comparable with the screw or even greater.[16,26] As suture anchor is expensive, FiberWire suture may be a reasonable fixation option. especially in developing countries.

Bogunovic et al.[7] performed a systematic review and demonstrated that compared with suture fixation, there is significantly greater clinical anterior knee laxity following screw fixation. However, the percentage of patients who returned to sport and the percentage of cases needing further ACL reconstruction was not significantly different between the 2 methods in the study of Bogunovic et al.[7]

For fracture fixation using suture, the technique may be based on passing the suture either through the tibial eminence fragment or the ACL tissue just above its insertion site. The latter option eliminates the risk of further fragment comminution and can be applied even for fixation of the small fragment.[21]

Different ACL biting techniques use 1,[27,28] 2,[21,29,30] 3,[31] or 4[17] fixation points to attach the avulsed fragment to the tibia. Our technique applies 2 fixation points for this purpose. This makes the procedure easier without sacrificing the reduction stability against future displacement or malrotation. However, more studies may give a better understanding on the optimal number of suture fixation needed.

Among different pullout suture techniques, the number of tibial tunnels is also a matter of debate. Tibial tunnels range from 1 to 4 in different studies.[17,32-34] Reduction of ACL avulsion with only 1 tunnel is difficult and relies on keeping the posterior soft-tissue connection between the fractured fragments intact.[33] Greater numbers may enable the surgeon with a greater ability to reduce fracture. However, it also may be associated with a greater risk of physeal injury in young patients or bone fracture. Therefore, similar to many published studies,[19,34] we selected to use 2 tibial tunnels.

The most common complications of arthroscopic fixation of ACL avulsion include arthrofibrosis, decreased knee range of motion, remained anterior knee laxity, and fracture nonunion. Complete irrigation and debridement of the fracture site is essential as it prevents fracture non-union. Removing any loose

Table 2. Advantages and Disadvantages of ACL Avulsion Fixation With FiberWire and Suture Disc

Advantages	Disadvantages
It can be applied in comminuted fractures.	
Limited soft-tissue damage.	Technically demanding.
Faster recovery.	Time-consuming if one does not follow the steps.
Maintenance of the proprioception.	Risk of iatrogenic bone-bridge fracture.
Cost effective.	The technique has not been evaluated in published clinical outcome studies.
the surgeon can evaluate and address other possible associated intra-articular injuries (e.g., meniscal injury).	Risk of suture cutting through the ACL, especially if the suture bite is within the ACL's synovial cover.
No need to device removal.	Risk of alteration in biomechanics of the joint by resection of the intermeniscal ligament.
Possibility of later MRI studies as no hardware is used in the knee.	The surgeon may be obliged to remove the suture disc in the future, which in turn may accompany possible risks including infection.
Simple technique.	The ACL vascular supply may be altered by the applied ligament sutures.

ACL, anterior cruciate ligament; MRI, magnetic resonance imaging.

bodies is necessary to decrease the risk of knee motion limitation. Also, early aggressive rehabilitation further improves the postoperative knee motion.[19]

Among the advantages of our technique, we can mention is that it can be applied in comminuted or simple fractures independent of whether the growth plate is open. Using arthroscopic method, enables the surgeon to minimize the soft-tissue injury and helps the surgeon to evaluate the other possible associated knee injuries (i.e., meniscus). Using ACL suture bite tied around medial and lateral ACL border enables the surgeon to better control the position of the fractured fragment and makes the reduction easier. Finally, it eliminates the need for a second surgery for removing the inserted hardware.

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