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CONTEMPORARY APPROACHES IN ORTHOPEDIC SURGERY: ARTHROSCOPIC MANAGEMENT OF ANTERIOR CRUCIATE LIGAMENT (ACL) AVULSION FRACTURES USING FIBERWIRE SUTURE AND SUTURE DISC

Orthopaedics

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ABSTRACT

The management of displaced tibial avulsion fractures continues to be a topic of debate in orthopedic surgery. Traditional open reduction and internal fixation methods carry risks of soft-tissue injury and arthrotomy-related morbidity, prompting a growing preference for arthroscopic approaches. Literature has proposed various fixation devices including sutures, K wires, and screws. However, screws may not be suitable for small or comminuted fractures, while K wires and sutures may lack adequate stability. The emergence of ultrahigh molecular weight polyethylene sutures such as FiberWire has revolutionized the treatment landscape, allowing for effective fixation even in cases of comminuted avulsion fractures. This paper presents a straightforward arthroscopic technique utilizing FiberWire for the management of displaced tibial eminence avulsion fractures.

KEYWORDS

Displaced tibial avulsion fractures, FiberWire, Anterior cruciate ligament.

INTRODUCTION

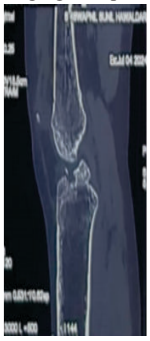
Anterior cruciate ligament (ACL) avulsion fractures, also known as tibial spine fractures, are relatively uncommon, with an estimated annual incidence of 3 per 100,000. [1,2] However, their occurrence is on the rise due to increased participation in sports among children and higher rates of high-energy motor vehicle accidents in adults. This injury is predominantly observed in individuals aged 8 to 14 years [3,4], contributing to 2-5% of cases of post-traumatic knee hemarthrosis and 14% of pediatric ACL injuries.

Operative intervention is generally recommended for displaced fractures (>2 mm), classified as type 2 or type 3 to 4 according to the modified Meyers and McKeever classification [5,6]. Surgical management has shown to reduce postoperative anterior knee laxity and decrease the likelihood of future ACL reconstruction[2,7,8]. Despite ongoing debate regarding the optimal surgical approach, arthroscopic reduction and fixation have gained popularity due to their minimally invasive nature and reduced risk of soft tissue damage. Various fixation methods, such as screws, staples, tension wiring, K wires, suspensory fixation, sutures, and anchor sutures, have been employed for arthroscopic repair of ACL avulsion fractures.

This article outlines our technique for arthroscopic fixation of ACL avulsion fractures and provides a comprehensive review of its advantages and disadvantages in managing this specific injury.


Figure No 1


Figure No 2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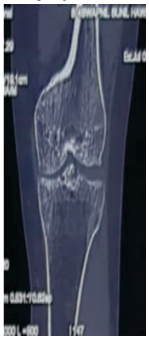
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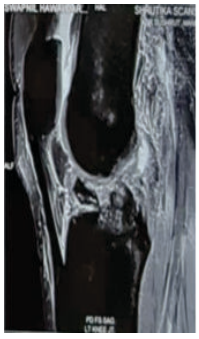
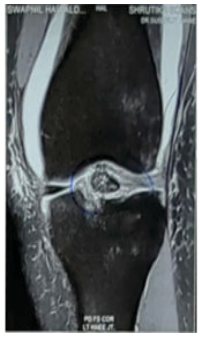
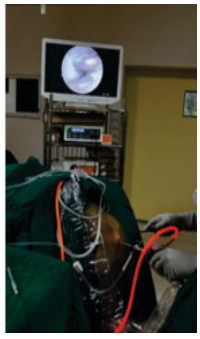
Figure No 5 Figure No 6 Figure No 7

Figure 1&2 shows Xray AP and Lateral views of ACL avulsion fracture. Figure 3&4 shows CT scan sagittal and coronal cuts of ACL avulsion fracture. Figure 5&6 shows MRI scan sagittal and coronal view of ACL avulsion fracture. Figure 7 shows knee arthroscopy going on in the patient

Procedure

Following spinal anesthesia, the patient is positioned supine, and a tourniquet is applied to the proximal thigh. Similar to conventional ACL reconstruction, the knee and calf are positioned at a 90-degree angle off the surgical bed with a leg holder to facilitate unrestricted knee movement.

Intravenous administration of cefazolin (2 g) and tranexamic acid (1 g) is given. After preparing and draping the surgical site, landmarks for patella, patellar tendon, anterolateral, and anteromedial portals are identified and marked. Sterile adhesive drapes are applied, and the tourniquet is inflated to 250-300 mm Hg. An arthroscopic system with anteromedial working and anterolateral visual portals is employed. Hematoma at the fracture site is evacuated, and any obstructing interposed tissues (e.g., intermeniscal ligament) are removed to facilitate fragment reduction. Diagnostic arthroscopy is performed to assess for concurrent knee joint lesions (e.g., ACL, meniscus).

Using an arthroscopic shaver, the crater of the fracture fragment is debrided to prepare for reduction. A cannula is inserted at the

anteromedial portal, and two separate FiberWire sutures (Arthrex, Naples, FL) are chosen. Using a 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. A FiberWire suture is tied over each border (lateral and medial) of the ACL using an arthroscopic sliding knot.

Figure 8 Shows Arthroscopic View Of ACL Avulsion.

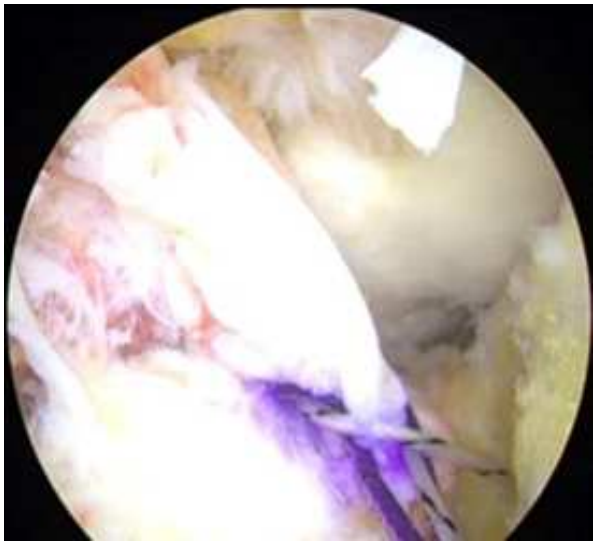

Figure 9 Shows ACL Avulsion Repaired With Fiberwire Sutures.

A longitudinal incision is made on the anteromedial tibia, 4 cm below the joint line. Two 2.7-mm tibial tunnels are created using 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. The proximal ends of the tunnels are positioned laterally and medially relative to the fractured fragment, approximately 1 cm apart. The K wires are then removed. A suture retriever (Arthrex) is used to pull the ends of the medial suture through the medial tunnel and the lateral suture through the lateral tibial tunnel. Following fracture reduction with a probe, the two FiberWires are tied together over a suture disc with the knee flexed at 20 degrees.

Subsequently, stability of fixation is assessed throughout the range of knee motion, and the joint is irrigated before closure of the surgical wound. Postoperatively, the knee is immobilized in a hinged knee brace locked in full extension. Range of motion exercises are gradually increased to achieve 120 degrees of flexion within 6 weeks. Weight-bearing is restricted for the first 2 weeks, followed by initiation of partial weight-bearing. At 8weeks post-surgery, the brace is discontinued, and the patient is permitted full weight-bearing.

DISCUSSION

Since Poncet [8] first described ACL avulsion fractures in 1875, various surgical approaches have been introduced. McLennan's 1982 study [9] highlighted the advantages of arthroscopic fixation, emphasizing reduced soft tissue damage compared to open techniques. Despite these advancements, debates persist regarding the optimal fixation device for arthroscopic procedures. The small size of the ACL insertion area on the tibial eminence (18 × 19 mm) poses technical challenges for fracture fixation via arthroscopic portals [10]. Long-term studies, such as Baxter and Willey's follow-up of 45 patients over 3 to 10 years, noted persistent extension lag and anterior laxity postoperatively in some cases [11].

Screws offer theoretical advantages due to their strong fixation capability. However, in cancellous bone like the proximal tibia, their actual rigidity may be compromised. Potential complications include ACL tear, fragment avulsion, impingement during knee extension, and neurovascular compression, necessitating hardware removal in a subsequent operation. In contrast, K wires are suitable for smaller fragments and pose less risk to the proximal tibial physis, making them safer for adolescents. Nonetheless, their fixation strength is limited, often requiring prolonged immobilization and exacerbating postoperative complications such as extension lag and restricted range of motion.

Suture and suture anchors [2] provide versatile fixation options irrespective of fragment size or patient age, eliminating the need for hardware removal. Studies suggest that high-strength sutures like FiberWire can achieve comparable or superior stiffness to screws. Considering cost-effectiveness, FiberWire may be particularly advantageous in resource-limited settings. Bogunovic et al.'s systematic review highlighted greater anterior knee laxity with screw fixation compared to suture fixation, though outcomes regarding return to sport and need for ACL reconstruction were comparable [7].

Techniques for suture fixation may involve passing sutures through the tibial eminence fragment or just above the ACL insertion to minimize fragment comminution risk, suitable even for small fragments. Our approach utilizes two fixation points, balancing procedural simplicity with stability against displacement or malrotation. However, further research is warranted to determine the optimal number of suture fixation points. Debates also surround the number of tibial tunnels in pullout suture techniques, ranging from 1 to 4 in different studies. While multiple tunnels may enhance fracture reduction capability, they also increase the risk of physeal injury in young patients or bone fracture. Aligning with previous studies, we opted for two tibial tunnels to balance reduction effectiveness with safety considerations.

Common complications of arthroscopic ACL avulsion fixation include arthrofibrosis, reduced knee range of motion, persistent anterior knee laxity, and fracture nonunion. Ensuring thorough irrigation, debridement, and removal of loose bodies are crucial to prevent nonunion and motion limitation, complemented by aggressive early rehabilitation to optimize knee function.

Our technique offers advantages in managing comminuted or simple fractures regardless of physeal status, utilizing arthroscopy to minimize soft tissue trauma and assess concurrent knee injuries such as meniscal damage. The use of ACL suture bites around the medial and lateral borders enhances fragment control and simplifies reduction, obviating the need for hardware removal in subsequent surgeries.

Pearls and Pitfalls of ACL Avulsion Fixation Using FiberWire and Suture Disc

Pearls

- Secure knee positioning using a leg holder enhances surgical visibility.
- Thorough irrigation and debridement at the fracture site mitigate the risk of non-union.
- Removal of loose bodies is essential to minimize knee motion restriction.
- Use of a cannula facilitates smooth passage of sutures and arthroscopic instruments through the anteromedial portal.
- Passing the suture above the ACL insertion site reduces the risk of fragment comminution, suitable even for small fragments.
- Dual fixation points (medial/lateral ACL halves) aid in precise control and Maintenance of fragment reduction.
- Verification of reduction integrity and assessment for potential knee extension impingement before Knotting on the suture disc. The disc prevents FiberWire from cutting into the bone.

Pitfalls

- Ensuring accurate fragment reduction and appropriate ACL tension before final suture knotting is crucial to prevent anterior knee laxity.
- Knotting sutures on the suture disc should occur with the knee flexed at 20 degrees to avoid potential extension gaps.
- Careful attention during postoperative rehabilitation is necessary to prevent FiberWire from cutting through the ACL with thin suture bites.

Table 1: Advantages And Disadvantages Of ACL Avulsion Fixation With Fiberwire And Suture Disc

DISADVANTAGES
1) Technically demanding.
2) Time-consuming if procedural steps are not followed meticulously.
3) Lack of evaluation in published clinical outcome studies.
4) Risk of iatrogenic bone-bridge fracture.
5) Potential for suture cutting through the ACL, particularly within the synovial cover.
6) Risk of biomechanical alterations due to sintermeniscal ligament resection.
7) Possibility of future suture disc removal, associated with infection risks.
ADVANTAGES
1) Applicable in comminuted fractures.
2) Minimal soft-tissue damage.
3) Accelerated recovery.
4) Suitable for patients of varying ages; eliminates the need for device removal.
5) Preserves proprioception.
6) Comparable stiffness to screws with high-strength sutures like FiberWire.
8) Cost-effective, particularly in developing countries.
9) Allows concurrent evaluation and management of intra-articular injuries.
10) No requirement for hardware removal.
11) Facilitates future MRI studies without metal artifacts.
12) Simplified technique.
13) Potential alteration of ACL vascular supply due to ligament sutures.

CONCLUSION

Suture wire fixation for ACL avulsion fractures is a reliable and effective treatment option that supports favorable recovery outcomes when combined with appropriate surgical technique and rehabilitation.

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