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All-Inside Anterior Cruciate Ligament Reconstruction Using Hamstring Tendon Autograft in Skeletally Immature Patient: A Case Report

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ABSTRACT

Introduction: The "all-inside" technique is a recent approach that aims to minimize surgical trauma and improve graft placement in anterior cruciate ligament (ACL) reconstruction. Pediatric patients require a different surgical approach than adults since they still have growth plates and are at risk of epiphyseal damage and growth arrest during surgery.
Aim: This case report aimed to report all-inside ACL reconstruction in a skeletally immature patient.
Case Presentation: A 13-year-old boy presented with a painful left knee since falling at school six months ago. Physical examination of the left knee revealed joint instability, limited range of motion, and a positive Lachman test. Magnetic Resonance Imaging (MRI) showed an ACL tear. We performed an arthroscopic all-inside ACL reconstruction using a hamstring autograft. Sockets were created in the femur and tibia using specialized instruments, and the graft was secured within these sockets using suspensory fixation devices. No bone tunnels were drilled through the full thickness of the bone. After the surgery, the patient felt no more pain in his left knee and was more stable when standing. He was able to resume his daily activities at school without pain.
Discussion: The advantages of an all-inside approach in skeletally immature patients compared to traditional outside-in techniques are smaller incisions, reduced surgical dissection, less pain, quicker recovery, preserved bone stock, reduced complication risk, and facilitated anatomic graft placement.
Conclusion: The all-inside ACL reconstruction technique using hamstring grafts can be performed successfully in a skeletally immature patient.

Keywords: Hawkins classification, open reduction internal fixation (ORIF), talar neck, talonavicular dislocation, talus fracture.

INTRODUCTION

Sports injuries among children and adolescents have increased significantly in the last two decades, with an annual increase of 2.3%, and approximately a quarter of all knee injuries occurred in this age range. Anterior cruciate ligament (ACL) tears occur in approximately 121 cases per 100,000 individuals yearly. The incidence peaked at age 17. Revision surgery rates in patients under 21 are 7.76 times higher.[1-3]

ACL reconstruction is a surgical procedure to restore knee stability and function after an ACL injury. Traditional ACL reconstruction techniques involve creating drill holes in the femur and tibia to pass a graft (typically an autograft from the patient's tissue or an allograft from a donor) through these bone tunnels. This method, known as the "outside-in" approach, requires significant surgical dissection and can potentially cause complications such as fractures, nerve or blood vessel injuries, and graft impingement.[4]

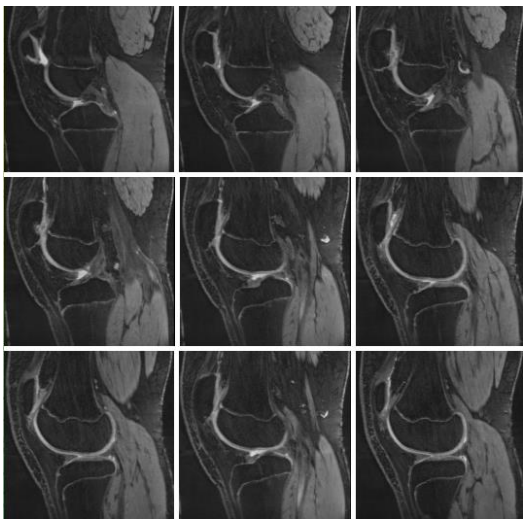
The "all-inside" ACL reconstruction technique is a relatively newer approach that aims to minimize the surgical trauma associated with the traditional method. This technique involves creating sockets or tunnels within the bones using specialized devices without drilling through the full thickness of the bone. The graft is then secured within these sockets using suspensory fixation devices or interference screws.[5]

Pediatric patients require a different ACL reconstruction approach than adults since they still have growth plates. The surgery of skeletally immature individuals with ACL rupture is considerably more complicated, given the risks of epiphyseal damage and growth arrest during surgery.[6,7] This case report aimed to report all-inside ACL reconstruction in a skeletally immature patient, in accordance with the Surgical Case Report (SCARE) 2023 guidelines criteria.[8]

CASE PRESENTATION

History and Initial Examination

A 13-year-old Asian boy presented to the orthopaedic surgery polyclinic complaining of pain in his left knee. He had a history of falling at school six months ago with the left knee inward when landing. The pain worsens after prolonged activity and subsides with rest. The patient also feels unsteady when standing. There was no history of family members having similar conditions, allergies, congenital diseases, or chronic diseases. The patient was at Tanner stage 3. A physical examination of the left knee revealed joint instability, limited range of motion, and a positive Lachman test. Magnetic Resonance Imaging (MRI) showed an ACL tear (Figure 1).



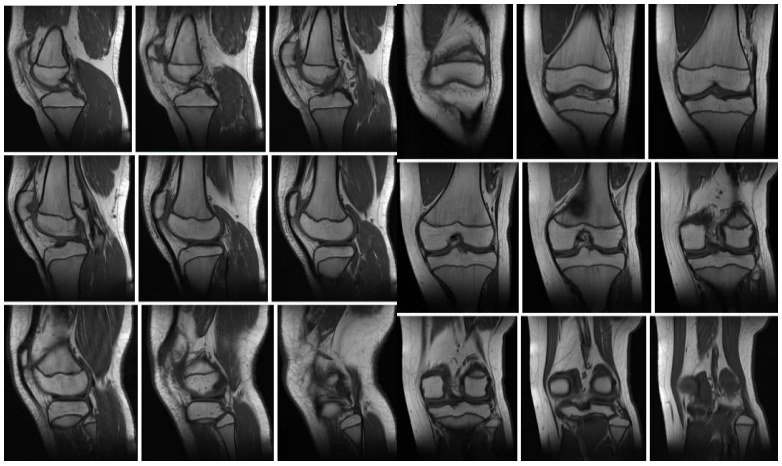


Figure 1. Preoperative MRI. The left knee's T2 and T1 weighted Magnetic Resonance Imaging (MRI) showed an anterior cruciate ligament tear.

Surgical Management

After discussion of risks, benefits, and alternatives, the patient and his parents consented to surgical intervention. The procedure began with preparing the hamstring autograft by harvesting the semitendinosus tendon. The graft length was approximately 50-55 mm, with a 7-8 mm diameter.

We then performed diagnostic arthroscopy through anteromedial and anterolateral portals to assess the knee joint and confirm the ACL tear. Using specialized retrograde drilling devices, we created sockets instead of full tunnels in both the femur and tibia. The femoral socket was created first, followed by the tibial socket. The sockets were then examined arthroscopically to confirm proper positioning and the absence of physeal injury.

The graft was then passed retrograde through these sockets and fixed using suspensory fixation devices on both ends, eliminating the need for incisions outside the joint capsule. We then adjusted the graft tension and tested the knee's range of motion and stability. Finally, the arthroscopic portals were irrigated and closed. The knee was treated with a sterile dressing and secured in a hinged knee brace locked in maximum extension. The patient was admitted to the hospital for one night. Physical rehabilitation began one day following surgery.

Postoperative Course and Rehabilitation

The surgery was uneventful. Postoperatively, the knee joint was kept in a ROM brace, and the patient underwent early physiotherapy. On the first postoperative day, he was instructed on partial weight-bearing status and began isometric exercises. The surgical wounds healed without signs of infection.

Follow-Up and Outcomes

The patient was evaluated clinically at regular intervals. After the surgery, the patient felt no more pain in his left knee and was more stable when standing. He was able to resume his daily activities at school without pain. Clinical examination showed no complication, and the left knee had a normal range of motion.

Intraoperative arthroscopic findings documented the procedure (Figure 2).

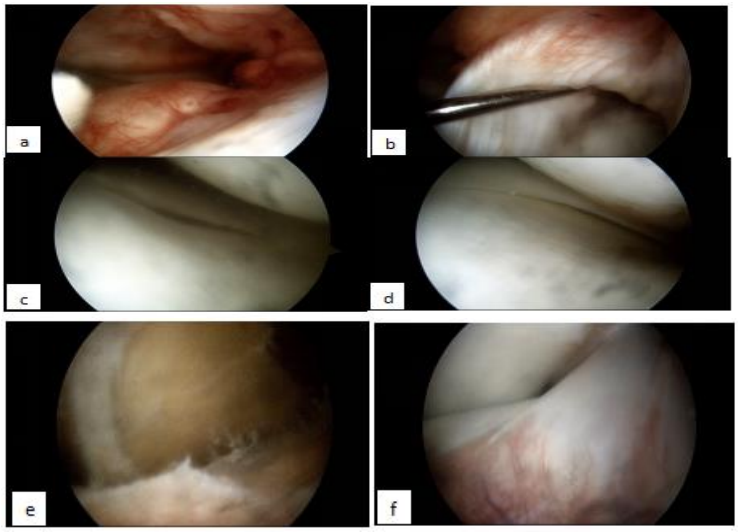


Figure 2. Intraoperative Arthroscopic Findings. (a) ACL remnant, (b) PCL, (c) lateral meniscus, (d) medial meniscus, (e) medial plica release, (f) anterior plica release

DISCUSSION

The anterior cruciate ligament (ACL) is one of the major ligaments in the knee joint, connecting the femur to the tibia. It plays a crucial role in stabilizing the knee joint and preventing excessive forward movement of the tibia relative to the femur. ACL injuries are common, particularly in athletes participating in sports that involve pivoting, cutting, and sudden stops, such as soccer, basketball, and skiing.[1]

The ACL anatomy in skeletally immature patients differs from that in skeletally mature patients. Younger patients typically have a more oblique ACL compared to older patients. ACL usually starts to grow around age 1.5 until 6, stabilization around age six until 12, and cessation around 18. In skeletally immature individuals, the ACL adheres to the perichondral cuff of the proximal tibia and distal femoral chondroepiphysis. As individuals age, this connection develops into the cartilage-bone junction observed in adults. The peri synovial sheath and terminal components of the tibia and femur provide blood circulation to the ACL in children and early adolescents. It is critical to determine the prospective closure of the physeal plate before performing ACL reconstruction.[1-3]

The incidence of ACL tear is highest among patients between the ages of 15 and 17. Due to rapid growth during puberty, there is an increasing torque force on the knee, raising the difficulty of muscular control and the likelihood of ACL injury. Given that they typically have two or three years or more of growth left, these individuals are especially vulnerable to growth abnormalities. The optimal therapy for ACL injuries in skeletally immature patients is still controversial. Despite the development of multiple distinct approaches, debate persists about which method provides the slightest danger to the patient while offering the best results. As the bone at the epiphyseal plate is still growing, it is recommended to avoid drilling through the epiphysis in skeletally immature individuals to prevent growth arrest. Therefore, physeal-sparing ACR reconstruction is recommended.[5,9]

Several additional factors must be considered during the clinical evaluation of pediatric patients with ACL injury. The history taking and physical examination in younger patients is usually more complex than in adults due to the inability to cooperate. Younger individuals may struggle to express detailed injury descriptions. It is advised to talk with parents or other witnesses about the incident. The patient's Tanner stage needs to be evaluated to determine the risk of growth disturbance after ACL reconstruction. The Tanner stage can be assessed through the assessment of secondary sexual

characteristics and inquiries about menarche, or using Greulich and Pyle atlas. Joint laxity may require examination on the other side of the knee. The gold standard of radiological assessment is MRI, which can be performed with sedation if needed. Some tertiary centers are starting to perform physeal sequences to assess maturity. CT scan and tomogram can be used if the bone maturity is doubtful.[10]

The best timing for ACL tear management depends on the age of the patients. It is recommended not to wait until skeletal maturity. A study showed that a 12-week delay was associated with meniscal and chondral injury.[11] In children with skeletal age under 15 with partial ACL tear, non-operative management might be considered. In prepubescent patients with substantial growth remaining (Tanner stage 1-2; males under 13 years old; females under 12 years old), it is recommended to do physeal-sparing autograft ACL reconstruction with modified MacIntosh/Micheli procedure or all-epiphyseal technique. If the patient already had puberty with limited growth remaining (Tanner stage ≥3; males >13 years old; females >12 years old), the recommended surgery is transphyseal autograft ACL reconstruction with soft tissue autograph and metaphyseal fixation.[11]

The all-inside technique uses specialized retrograde drilling devices to create the tibial and femoral bone tunnels without drilling through the full thickness of the bone. The graft is then passed through these tunnels and fixed on both ends without exiting the joint capsule. This technique often utilizes suspensory fixation devices for graft securement. The all-inside technique offers several potential advantages over the traditional approach, including (1) smaller incisions and less surgical dissection, leading to reduced surgical trauma, less pain, and potentially quicker recovery; (2) preservation of the bone stock, as no full-thickness bone tunnels are created, which may be beneficial for future surgical revisions or procedures; (3) reduced risk of complications associated with the traditional approach, such as fractures, nerve or blood vessel injuries, and graft impingement; (4) improved graft positioning and anatomic placement, potentially leading to better long-term outcomes.[4,5]

A case series on 23 skeletally immature athletes reported that all-inside ACL reconstruction resulted in improved Pediatric International Knee Documentation Committee score (Pedi-IKDC), Lysholm score, Marx activity rating scale score, and Hospital for Special Surgery Pediatric Functional Activity Brief Scale score, without any growth disturbances noted.[12] Another case series reported improved Pedi-IKDC score but 8% growth disturbance using a hybrid physeal-sparing technique.[7]

It is recommended that primary ACL reconstruction in skeletally immature patients should be performed with autograft. The graft used in this case was hamstring autograft. Hamstring autografts offer several advantages in ACL reconstruction. This technique involves using the patient's hamstring tendons, typically resulting in lower donor site morbidity and faster initial recovery than other graft options. Patients often experience less post-operative pain and quicker range of motion restoration. The procedure reduces the risk of anterior knee pain and complications associated with patellar tendon harvesting. Hamstring grafts provide excellent strength and stability for the reconstructed ACL while requiring smaller incisions, leading to less visible scarring. This approach is particularly suitable for younger patients, as it avoids potential growth plate disruption. The hamstring autograft method balances good clinical outcomes with reduced harvest site issues, making it a popular choice among surgeons and patients for ACL reconstruction.[13]

This case report had limitations. The single case nature inherently limits the generalizability of the findings. Longer-term follow-up is needed to definitively rule out late-onset growth disturbances or degenerative changes.

CONCLUSION

The all-inside ACL reconstruction technique using hamstring grafts can be successfully performed in a skeletally immature patient. Compared to traditional outside-in techniques, the all-inside approach offers several advantages, including smaller incisions, reduced surgical dissection, less pain, quicker recovery, preserved bone stock, reduced complication risk, and facilitated anatomic graft placement. This case demonstrates that this physeal-sparing technique can achieve excellent early clinical outcomes in appropriately selected pediatric patients.

Declaration by Authors

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