Ligament Augmentation as a Treatment for Partial Anterior Cruciate Ligament Injury with Bone-Patellar Tendon-Bone Autograft: Case Report

Aumentación ligamentaria como tratamiento de lesión parcial de ligamento cruzado anterior con autoinjerto hueso-tendón-hueso: Presentación de caso clínico

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Abstract

Anterior cruciate ligament (ACL) rupture is one of the most common knee injuries in young active patients, negatively impacting their sports activity. Clinical presentation typically includes a history of trauma accompanied by edema, pain, functional limitation, and a sense of joint instability. There are various clinical signs and MRI findings suggestive of the injury, although arthroscopy remains the definitive diagnostic method. Treatment goals aim to achieve optimal rehabilitation and functional recovery, early return to sports, and prevention of joint damage that could lead to premature knee degeneration. In partial tears, there is no consensus on whether to preserve the remaining bundle or perform total ligament reconstruction. Regarding the choice of surgical technique, anatomical reconstruction has been preferred, and for graft selection, autograft has been chosen, although there are different valid therapeutic options based on each patient's characteristics. This review presents the case of a 36-year-old male diagnosed with a partial ACL tear with an intact posterolateral bundle, following an axial load injury mechanism with the knee in flexion, clinically presenting with pain, limited mobility, and joint instability of the knee. Due to the patient's clinical and imaging characteristics, arthroscopy was chosen as the diagnostic and therapeutic method. Based on arthroscopic findings, ligament augmentation with a bone-patellar tendon-bone autograft was performed, due to the mechanical advantages of the anatomical positioning of the bone tunnels offered by the surgical technique, as well as the biological advantages, such as preservation of joint proprioception, bone integration, and functional benefits of graft selection.

Keywords

- anterior cruciate ligament
- ligament augmentation
- autograft
- bone-tendon-bone graft
- arthroscopy

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Resumen

La rotura del ligamento cruzado anterior es de las lesiones de rodilla más frecuentes en pacientes jóvenes con alta demanda funcional, repercutiendo de manera negativa en su actividad deportiva. El cuadro clínico se caracteriza por el antecedente de traumatismo con aparición de edema, dolor, limitación funcional y sensación de inestabilidad articular. Existen diversas maniobras clínicas y hallazgos en la resonancia magnética sugestivas de su lesión, aunque la artroscopia sigue considerado el método diagnóstico definitivo. Los objetivos del tratamiento están orientados en la rehabilitación y recuperación funcional óptima, el retorno deportivo temprano, así como en la prevención de desarrollo daño articular que condicione un desgaste prematuro de la rodilla. En el contexto de roturas parciales, no existe un consenso acerca de la preservación del fascículo remanente o la reconstrucción total del ligamento. En cuanto a la elección de la técnica quirúrgica se ha preferido la reconstrucción anatómica, sobre la elección del injerto se ha optado por la selección de autoinjerto, aunque existen diversas opciones terapéuticas válidas basadas en las características de cada paciente. En esta revisión se presenta el caso de un paciente masculino de 36 años con diagnóstico de rotura parcial del ligamento cruzado anterior con integridad del fascículo posterolateral, posterior a presentar un mecanismo de lesión de carga axial con la rodilla en flexión, clínicamente se presenta con dolor, limitación a la movilidad e inestabilidad articular. Debido a las características clínicas e imagenológicas del paciente se decidió realizar una artroscopia como método diagnóstico terapéutico. Con base en los hallazgos artroscópicos se optó por realizar una aumentación ligamentaria con uso de autoinjerto hueso-tendón patelar -hueso, esto debido a las ventajas mecánicas de la situación anatómica de los túneles óseos que ofrece la técnica quirúrgica, así como las ventajas biológicas, como la preservación de la propiocepción articular e integración ósea y funcionales de la selección del injerto.

Palabras clave

- ligamento cruzado anterior
- aumentación ligamentaria
- autoinjerto
- injerto hueso-tendón-hueso
- artroscopia

Introduction

The anterior cruciate ligament (ACL) is one of the two most important intra-articular fibrous ligaments of the knee, whose most important function is to provide rotational and translational stability. Its structure consists of fibroblasts located primarily in type I and type III collagen, as well as small amounts of type IV collagen in its insertion sites.[1] The ACL originates in the posteromedial region of the lateral femoral condyle and extends distally and anteriorly to insert just anterior to the intercondylar eminence on the tibia. The ACL is divided into two bundles: the anteromedial bundle (AMB) and the posterolateral bundle (PLB), with distinct footprints on their femoral and tibial portions, the latter of which gives rise to their names.[2] The two beams vary in function. AMB is mostly isometric, while PLB is anisometric. In extension, the AMB appears as a flat band and the PLB is tense. With progressive flexion the AMB becomes tense and the PLB begins to show some laxity. The AMB is primarily responsible for resisting anterior translation of the tibia in flexion, while the PLB resists rotation, hyperextension, and anterior translation of the tibia in extension.[3]

Partial ACL injuries can occur after a cutting or pivoting motion injury; however, the presentation differs from a complete tear. Frequently the patient associates a harmful triggering event with the onset of symptoms; however, patients may present vague symptoms and have a perception that their knee "feels different" compared to the contralateral knee.[4] Alternatively, the patient may describe an injury followed by obvious symptoms of instability and an inability to perform pivoting or cutting maneuvers, which are more consistent with a complete ACL tear.[5,6]

Within the diagnostic approach, magnetic resonance imaging is the most useful study to differentiate the morphology between a normal and an abnormal ACL, however, it is less reliable to determine and categorize the characteristics of partial injuries.[7] In T2-weighted images of the ACL, diffuse thickening and disorganization suggest a partial tear. Oblique images in the coronal, sagittal, and axial projections can help better outline the nature of the injury. Recently, two easily identifiable signs in routine MRI sequences have been described to help diagnose an isolated tear of the PLB: the 'gap sign' and the 'footprint sign.' The 'gap sign' is described as an increased signal in water-sensitive sequences between the lateral femoral condyle and the proximal portion of the ACL. The 'footprint sign' is observed in coronal images with increased signal correlating to an avulsion or involvement of the PLB at its tibial insertion.[8] Even in the context of suspicion, the accuracy of MRI for partial ACL tears is 25 to 53%, a challenging challenge for radiologists.[7] The diagnostic standard continues to be intraoperative confirmation in the context of a stable knee on physical examination.[9]

The primary determinant for selecting appropriate treatment in partial ACL tears depends on whether the ACL is

competent and functional. A functional partial tear of the ACL would be defined as one in which the athlete can return to their usual sporting activity with confidence in their knee and with minimal or no sensation of laxity in the physical examination after an appropriate rehabilitation period. On the other hand, a non-functional partial tear would be one in which the athlete is unable to return to their usual sporting activity because they present symptoms of instability when trying to carry out a more demanding sporting activity or there is evident laxity in the physical examination. An ACL reconstruction or augmentation is a procedure that is recommended for those patients who are unable to return to their desired level of activity with symptoms and physical examination findings associated with a non-functional partial ACL tear. Contact sports involving pivoting maneuvers (e.g., soccer, rugby, basketball, and American football) and an age of 20 years or younger have been notable factors reported to increase the risk of progression to a complete ACL tear.[10] The typical candidate for non-surgical treatment is a patient with a negative pivot shift test and less than 5 mm of anterior tibial translation, as measured by the arthrometer when compared to the contralateral knee, in addition to the ability to participate at the same level of sports activity.[10]

As part of conservative treatment, protocols lasting 3 months have been proposed, consisting of immobilization and rehabilitation in patients with a laxity difference <4 mm and reexamining the laxity difference after 3 months. If the patient remains stable, they can return to sports activity at that time.[11] A short period of immobilization is recommended to reduce edema and pain, followed by a functional rehabilitation program focused on maintaining mobilization and strength before progressing to specific sports activities.[9] When deciding on surgical treatment, the decision should be made based on the arthroscopic findings whether to do selective debridement and augmentation or opt for standard ACL reconstruction.

The decision is made based on the quantity and quality of the remaining fibers after debridement, as well as the surgeon's preference.[12] Several techniques have been described for selective reconstruction of AMB or PLB. Selective reconstruction follows the anatomical principles of double-band reconstruction that seeks to restore the individual anatomy and function of a bundle, without damaging the intact bundle. Femoral tunnel drilling has been described with different techniques such as all-in, over-the-top, transtibial, and anteromedial, all with good clinical and functional results.[13]

Case Study

A 36-year-old male patient with no clinically relevant medical or surgical history. One month before the evaluation, he sustained a right knee injury during contact sports, involving an axial load mechanism with the knee in flexion. Currently, he reports medial joint line pain, swelling, and a sensation of joint instability, with episodic exacerbation of symptoms during physical activity.

On physical examination, pain, range of motion, muscle group strength, and joint stability of the knee were assessed. The patient reported localized pain on the medial parapatellar surface along the joint line. Knee range of motion showed active flexion of 75°, passive flexion of 130°, and complete extension, both passive and active. Muscle strength was diminished (4/5 on the Daniels scale) with the knee flexed beyond 45°, but full strength (5/5) was observed with the knee in extension. Special tests were performed to evaluate meniscal and ligamentous structures of the knee. Both valgus stress (bostezo) and meniscal tests were negative. Anteroposterior ligament stability was assessed using the Lachman test, which was negative. However, the anterior drawer test at 30°, 60°, and 90° showed increased anterior tibial translation compared to the contralateral limb at 60° and 90°.

As part of the diagnosis, a simple MRI of the knee was performed to assess joint ligamentous injuries. Among the findings, thinning of the anterior cruciate ligament was observed, peri-ligamentary inflammatory fluid with increased intensity, compatible with an anterior cruciate ligament injury (►**Fig. 1**). The rest of the intra-articular anatomical structures were found without injuries.

Based on the clinical and imaging findings, the diagnosis of rupture of the anterior cruciate ligament of the right knee was made. Due to the patient's symptoms and joint instability, a therapeutic diagnostic procedure was proposed using arthroscopy to confirm the rupture of the anterior cruciate ligament, with the possibility of performing a reconstruction using patellar tendon autograft.

In the operating room, the patient was examined again under balanced general anesthesia. The pivot shift maneuver was positive. We proceeded with the surgical phase of arthroscopy, revealing a partial rupture of the anterior cruciate ligament with involvement of the anteromedial bundle (►**Fig. 2**). The tension and stability of the posterolateral bundle were evaluated, evidencing its competence, so it was decided to perform a ligamentous augmentation with a patellar tendon autograft, proceeding to obtain the graft.

The anterior tibial tuberosity was located, and a longitudinal incision was made to identify the insertion site of the patellar tendon. A graft measuring 3 cm in length and 1 cm in width was marked distally. The graft was harvested using an oscillating saw, making cuts 1 cm in depth. A second horizontal incision was made between the arthroscopic portals to locate the distal edge of the patella. The peritendon was incised to identify the origin of the patellar tendon, and a graft was marked on the patella measuring 2.5 cm in length, 1 cm in width, and 1 cm in depth. The graft was harvested using a saw. A bone-tendon-bone (BTB) graft was obtained, including two bone blocks (proximal and distal) and the patellar tendon. The graft was prepared in vancomycin with a configuration of 9 mm in width, a femoral bone block of 25 mm, and a tibial bone block of 30 mm.

The arthroscopic examination was continued, checking the integrity of the menisci, ruling out meniscal and articular cartilage injury, and adequate patellar tracking was observed. The lateral condylar notch was measured at 26 mm, a microfracture was made 12 mm from the posterior cortex, a retrograde femoral guide was placed at 105°, and a 25 mm bone socket was made retrogradely. The tibial tunnel

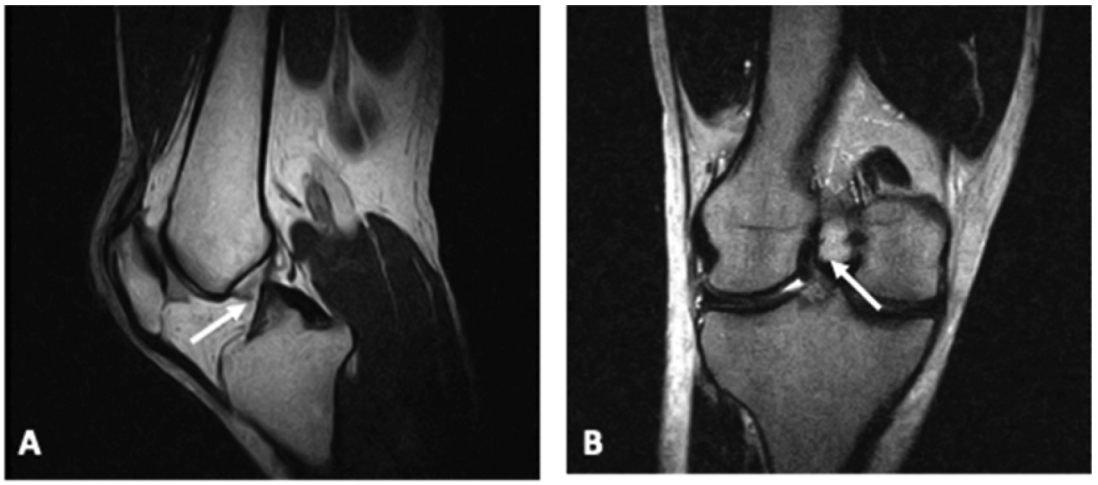

Fig. 1 Simple MRI of the right knee in T2 sequence. (A) Sagittal view; (B) Coronal view. Thinning of the anterior cruciate ligament is observed.

guide was placed at 55° and drilled outside and inside in the tibial footprint with a 10 mm drill bit.

The BTB graft was passed by pulling sutures from the external surfaces of the femur and tibia and inserting the bone blocks into the previously prepared bone tunnels (►**Fig. 3**). An 8 × 26 mm biocomposite screw was inserted in the femur (►**Fig. 3**). The knee was cycled, and with the knee in full extension, the tibia was fixed using an 8 × 30 mm biocomposite screw. The anatomical positioning of the ACL graft was observed, confirming proper tension and stability of the reconstructed ligament (►**Fig. 4**).

The patient left the operating room in stable condition, with a cryotherapy and compression system, analgesic, and anti-inflammatory scheme. Passive movements were initiated in the immediate postoperative period, and support was given for tolerance of the extremity. He went home 12 hours after surgery. After 2 weeks, the stitches were removed and management with physiotherapy and rehabilitation began, focused on the recovery of the range of motion, muscle strengthening of the quadriceps, and gait re-education. Currently, 3 months after surgery, the patient is asymptomatic, with active ranges of motion with a flexion of 115°, full extension, strength of 5/5, and clinical stability of the anterior cruciate ligament.

Discussion

Rupture of the anterior cruciate ligament is one of the most common sports injuries in young athletes. Partial injuries of the anterior cruciate ligament represent 9 to 28% of the total of these injuries.[7] The definitive diagnosis of this type of partial injury has not yet been established concisely, among the suggestive diagnostic criteria are clinical, imaging findings, and arthroscopic.[7] In the case of our patient, the criterion for carrying out surgical intervention in the context of partial ACL rupture was joint instability.[9]

Once the arthroscopic diagnosis has been corroborated and the adequate integrity of the remaining bundle has been observed, it is decided to preserve it, since biological, clinical, and functional benefits have been described regarding preserving the remaining bundle of the ligament. The preservation of the remaining fascicle of the anterior cruciate ligament maintains a cellular and vascular environment that promotes the integration of the graft, while maintaining

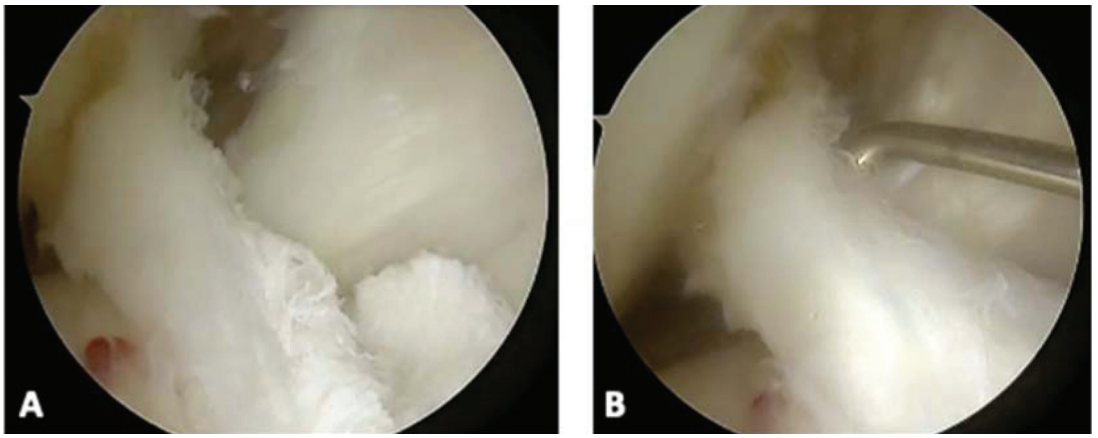

Fig. 2 Arthroscopic image of the knee. (A) A partial tear of the anterior cruciate ligament is observed, with integrity of the posterolateral bundle. (B) The anatomical and functional competence of the posterolateral bundle is confirmed.

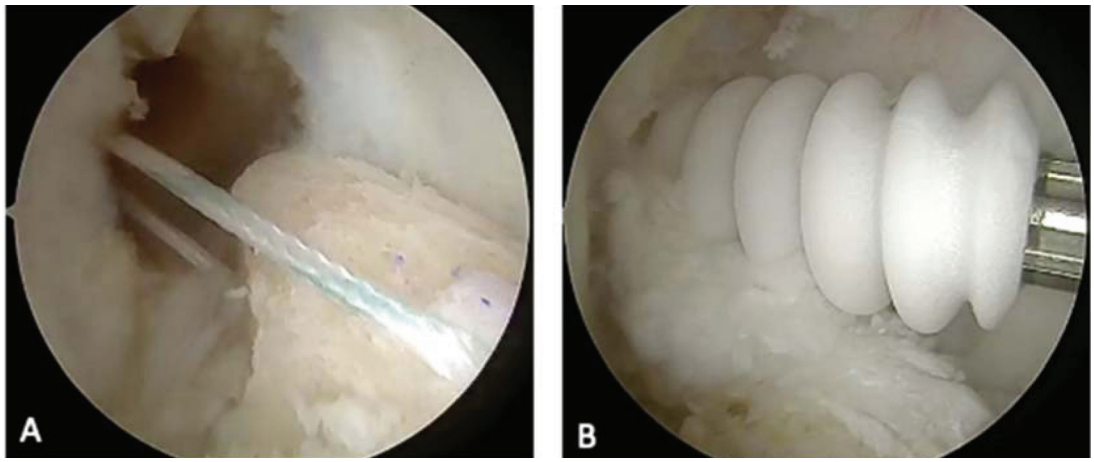

Fig. 3 Arthroscopic knee image. (A) Femoral bone tunnel made with retro construction, the passage of the bone pad of the graft is observed. (B) Fixation of the bone pad in the femoral tunnel with a biocomposite screw.

Fig. 4 Arthroscopic knee image. BTB ligament graft of anteromedial bundle, placed in anatomical situation.

its cellular properties, such as ligamentous proprioception, promoting a prompt recovery of the ranges of mobility and an early onset of physical rehabilitation.[14,15]

Two of the most used methods to obtain autografts are the bone-patellar tendon-bone graft (BTB) and the hamstring graft. The BTB graft presents biological advantages compared to the hamstring graft, the integration present in the BTB, due to the bone tunnels and bone pads, presents a faster and more solid bone integration in the fixation sites, compared to the hamstring grafts that require biointegration of soft tissue with bone tissue.[16] This advantage in integration results in a faster recovery of knee stability, which is crucial for athletes and active people who want to return to their previous level of physical activity as soon as possible.[17] The BTB graft has been shown to have greater resistance to elongation and higher initial fixation strength compared to the hamstring graft. This resistance to elongation can translate into less postoperative laxity and greater joint stability, which is essential for sports activities that require rapid changes of direction and high-intensity movements.[17] Long-term studies have indicated that patients with BTB grafts have lower rates of graft failure and fewer complications related to residual knee laxity. Although both types of grafts have good short-term outcomes, evidence suggests that BTB grafts may offer advantages in terms of long-lasting joint stability and lower reintervention rates.[16]

The use of hamstring grafts may compromise muscle strength in the knee flexor muscle group, which could negatively impact athletic performance and overall knee stability.[18] In contrast, the use of BTB avoids this complication, as the donor site is the patellar tendon, which has less impact on overall muscle function compared to the hamstrings.[18]

Although BTB grafting may be associated with increased postoperative pain and a higher incidence of donor site morbidity, such as patellar tendinitis and anterior knee pain, careful patient selection and appropriate postoperative management can mitigate these effects.[17]

The femoral retroconstruction technique allows for more anatomical positioning of the bone tunnel and graft to the femur. This results in better restoration of knee biomechanics and greater postoperative stability. It also offers the advantage of preserving a greater bone stock with the integrity of the femoral cortex.[19]

Conclusions

In conclusion, arthroscopic ACL augmentation, preserving the remnant bundle as a therapeutic option for partial tears, offers biological, clinical, and functional advantages compared to anatomical reconstruction. Regarding autograft selection (BTB and hamstring), both are viable options for ACL reconstruction. BTB grafts provide functional benefits in both the short and long term, as well as a lower reoperation rate. The choice of graft type should be personalized, taking into account the biomechanical and clinical advantages, as well as the potential complications associated with each graft type. The selection of technique and graft can enhance surgical outcomes and patient satisfaction in the treatment of partial ACL tears, facilitating an earlier return to sports or recreational activities.

Ethical Considerations

It was not experimented on any patient; it was only the presentation of a clinical case.

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No member of the research team receives external funding or benefits from political affinities, family relationships, or any type of common interests.

Conflict of interest

The team of doctors participating in the clinical case presented under the name: "Ligament augmentation as a treatment for partial anterior cruciate ligament injury with bone-patellar tendon-bone autograft: case report" declares that it has no conflict of interest as it is not commercially related to any sponsorship.

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