

Modification of the Micheli-Kocher Technique with Anterior Cruciate Ligament Remnant Preservation and Augmentation in Pediatric Patients: A Technical Note

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ABSTRACT

Objective: To describe a modification of the Micheli-Kocher technique that incorporates anterior cruciate ligament (ACL) remnant preservation and augmentation to enhance biological potential in skeletally immature patients. **Materials and Methods:** The surgical procedure is described in an 8-year-old boy (Tanner stage I) who competes in motocross. The key modification involves using an arthroscopic shaver to create an oblique opening in the superolateral portion of the remnant, through which the iliotibial band graft is passed. This allows the remnant tissue to provide biological support and guide the neoligament. **Results:** At the 12-month follow-up, the patient's knee was clinically stable (negative Lachman and pivot-shift tests), and radiographs showed no limb length discrepancies or angular deformities. He successfully returned to high-impact competitive sport (motocross), with marked proprioceptive recovery and full range of motion. **Conclusions:** This technical modification combines the mechanical safety of extrap- hyseal reconstruction with the potential biological benefits of remnant preservation. The technique was a safe alternative in this single case; however, studies with a higher level of evidence are needed to confirm its comparative advantages in ligamentization and proprioception.

Keywords: Anterior cruciate ligament; pediatrics; Micheli-Kocher technique; remnant preservation; iliotibial band.

Level of Evidence: IV

Modificación de la técnica de Micheli-Kocher con preservación y aumentación del remanente del ligamento cruzado anterior en pacientes pediátricos: nota técnica

RESUMEN

Objetivo: Describir una modificación de la técnica de Micheli-Kocher que integra la preservación y aumentación del remanente del ligamento cruzado anterior (LCA) para mejorar el potencial biológico en pacientes con inmadurez esquelética. **Materiales y Métodos:** Se detalla el procedimiento quirúrgico en un varón de 8 años (Tanner I), piloto de *motocross* competitivo. El paso distintivo consiste en realizar, con una rasuradora para artroscopia, un ojal oblicuo en la región superolateral del remanente para el pasaje del injerto de banda iliotibial, de modo que el tejido remanente actúe como soporte biológico y guía del neoligamento. **Resultados:** A los 12 meses de seguimiento, el paciente tenía una estabilidad clínica completa (pruebas de Lachman y del pivote negativas), sin disimetrías ni alteraciones angulares en las radiografías. Se reintegró, con éxito, a la competición de alto impacto (*motocross*), la recuperación propioceptiva fue notable y el rango de movilidad, completo. **Conclusiones:** Esta modificación técnica combina la seguridad mecánica de la reconstrucción extrafisaria con el aporte biológico potencial de la preservación del remanente. En este reporte de un único caso, la técnica resultó ser una alternativa segura; no obstante, se requieren estudios de mayor nivel de evidencia para confirmar sus ventajas comparativas en términos de ligamentización y propiocepción.

Palabras clave: Ligamento cruzado anterior; pediatría; técnica de Micheli-Kocher; preservación del remanente; banda iliotibial.

Nivel de Evidencia: IV

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How to cite this article: Cucalón GR, Fernández-Staudacher G, Veloz Serrano D. Modification of the Micheli-Kocher Technique with Anterior Cruciate Ligament Remnant Preservation and Augmentation in Pediatric Patients: A Technical Note. *Rev Asoc Argent Ortop Traumatol* 2026;91(5):503-509. <https://doi.org/10.15417/issn.1852-7434.2026.91.5.2315>

INTRODUCTION

Managing anterior cruciate ligament (ACL) tears in children requires a careful balance between restoring joint stability and protecting the physes. In prepubescent patients with substantial skeletal immaturity (Tanner stages I and II), traditional transphyseal techniques carry a documented risk of growth arrest and angular deformity.¹

To address this challenge, Kocher, Garg, and Micheli described a combined intra- and extra-articular, physeal-sparing reconstruction technique using an iliotibial band (ITB) autograft, deliberately avoiding bone tunnels that cross the femoral or tibial physes.¹ The technique has demonstrated long-term safety and effectiveness, with excellent rates of return to sport² and robust fixation owing to the versatility and strength of the ITB.³

However, the standard technique does not routinely preserve the ACL remnant, which has received increasing attention in the recent medical literature for its biological potential. Recent systematic reviews suggest that remnant preservation is superior to the standard technique in terms of revascularization and proprioceptive recovery⁴ and may provide better clinical and functional outcomes.⁵

Although several pediatric techniques have been described,⁶ no previous reports have specifically combined the Micheli–Kocher technique with remnant preservation. The indication for this technique was an anteromedial bundle tear with a mechanically stable posterolateral bundle remnant containing vascularized synovial fibers. Selective debridement of the intercondylar notch was performed to preserve this native tissue.

This technical note describes a surgical modification intended to combine the safety of an extraphyseal approach with the benefits of biological preservation.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee. Written informed consent was obtained from the patient's parents for the procedure and publication of the case report. Anonymity and protection of the patient's personal data were ensured in accordance with applicable regulations.

Positioning and approach

The patient is placed supine, and an examination under anesthesia is performed to confirm the degree of instability. A longitudinal lateral incision approximately 8 cm long is made over the distal ITB and lateral femoral epicondyle, following the principles described for surgical exposure of the ITB.³

Graft harvest and preparation

Dissection proceeds through the tissue layers to expose the fascia lata. Two parallel incisions, 15–20 mm apart, are made in the distal ITB and extended proximally beneath the skin to obtain a graft of sufficient length, generally 16–18 cm (Figure 1). It is essential to preserve the distal ITB insertion at Gerdy's tubercle to maintain its native anatomical attachment. The proximal end of the graft is released, delivered through the wound, and tubularized using high-strength sutures in a Krackow configuration.

Arthroscopic phase and remnant management

Standard arthroscopic portals are established. In the original technique described by Kocher and Micheli, the intercondylar notch is debrided to clearly visualize the “over-the-top” position.¹ In this modification, debridement is selective. The ACL remnant is preserved, particularly when it retains a robust tibial attachment and vascularized synovial fibers.

Graft passage and integration with the remnant

The “over-the-top” passage is prepared by carefully dissecting the posterior capsule and periosteum along the posterior aspect of the lateral femoral condyle, taking care to avoid injury to the perichondral ring. The tubularized graft is passed deep to the lateral collateral ligament and introduced into the joint using the “over-the-top” technique (Figure 2).



Figure 1. Graft harvest and preparation. The lateral incision and isolated central strip of the iliotibial band are shown, with the distal attachment at Gerdy's tubercle preserved. The proximal end of the graft has been tubularized.



Figure 2. Arthroscopic view of the modified technique. The tubularized iliotibial band graft (white arrow) enters the joint through the "over-the-top" route and lies in close contact with the preserved native anterior cruciate ligament remnant (yellow arrow).

The key step, once the ITB graft is inside the joint, is to pass it through or adjacent to the preserved remnant. An arthroscopic shaver is used to create an oblique opening approximately 7 mm in diameter in the superolateral corner of the ACL remnant, following the orientation of its fibers and preserving as much viable tissue as possible. The ITB graft is then passed through this opening from posterior to anterior. If a size mismatch prevents smooth passage, the opening is gradually enlarged to match the graft diameter as closely as possible, while avoiding excessive resection of the remnant. The native tissue thus envelops the graft, providing biological and mechanical support that guides the orientation of the reconstructed ligament and maximizes tissue-graft contact for revascularization. No additional sutures are needed to secure the remnant to the graft.

Tibial fixation

The graft is pulled distally toward the tibia. Extraepiphyseal tibial fixation is achieved by passing the graft beneath the intermeniscal ligament and suturing it to the medial tibial periosteum (Figure 3). Fixation may be reinforced with staples or bone anchors placed distal to the anterior tibial physis, with appropriate tension maintained at 20°–30° of knee flexion.

Finally, full knee extension is checked clinically and arthroscopically to rule out graft impingement or interposition of the remnant within the intercondylar notch.



Figure 3. Tibial fixation. The graft is passed distally between the tibial surface and the intermeniscal ligament, then secured to the proximal tibia with extraepiphyseal fixation, avoiding the growth plate.

RESULTS

We present the case of an 8-year-old boy, a competitive motocross rider, who was skeletally immature (Tanner stage I). He sustained a knee injury, and an ACL tear was confirmed by magnetic resonance imaging (MRI) (Figure 4) and physical examination. Intraoperative assessment confirmed an anteromedial bundle tear with an intact posterolateral bundle and a viable tibial remnant.



Figure 4. Preoperative parasagittal MRI of the knee showing the anterior cruciate ligament tear.

The modified Micheli–Kocher technique with remnant preservation described above was performed. The post-operative protocol included immobilization in a long-leg splint for 6 weeks and progressive weight bearing as tolerated. At the 12-month follow-up, the knee was clinically stable, with negative Lachman and pivot-shift tests and a full range of motion. The patient had returned to his previous competitive level without pain or limitations. Follow-up radiographs showed no limb length discrepancy or angular deformity of the lower limbs. MRI showed a correctly positioned and oriented reconstructed ligament, without a horizontal course (Figure 5).

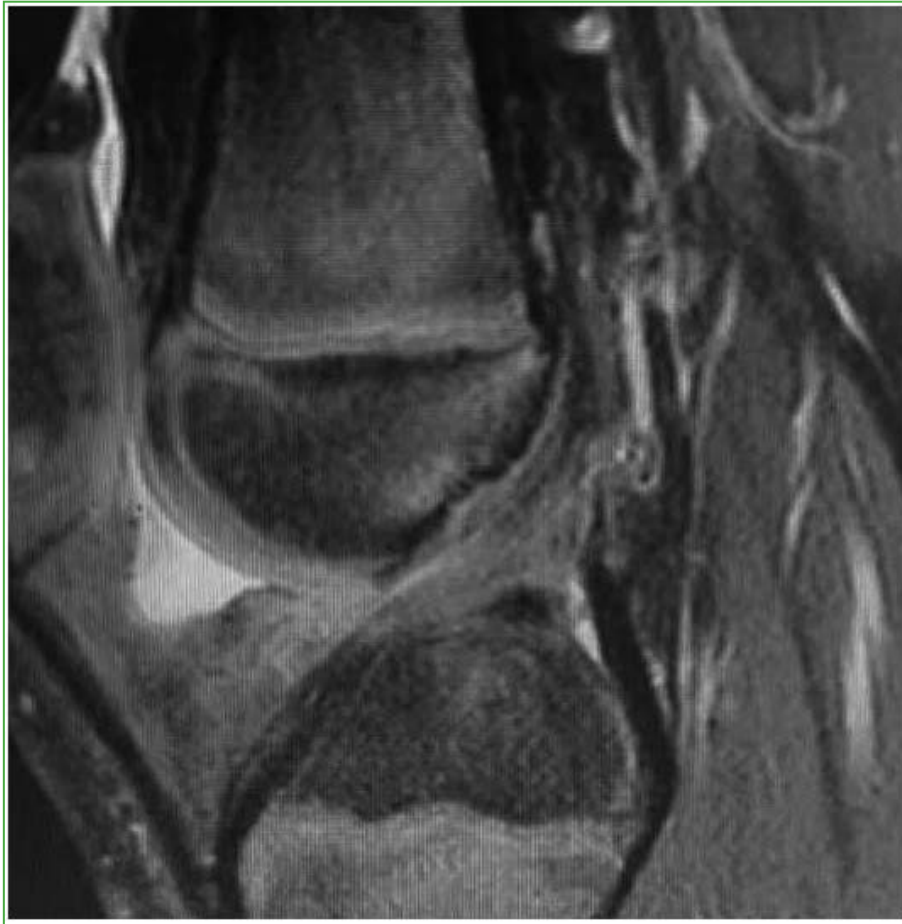


Figure 5. Postoperative parasagittal MRI of the knee showing the reconstructed ligament in the correct position and orientation, without a horizontal course.

DISCUSSION

ACL reconstruction in skeletally immature patients, generally aged 6–13 years, presents unique challenges. The Micheli–Kocher technique remains the procedure of choice because it fully spares the physes.^{1,2} Our modification aims to add a meaningful biological benefit to this mechanically established procedure.

The main rationale for preserving the remnant lies in the biology of “ligamentization.” The current medical literature suggests that remnant preservation may accelerate cellular repopulation and improve vascularization. Available evidence indicates that it may promote cellular repopulation, revascularization, and biomechanical graft integration.⁴ In our case, the successful return to motocross indicates good functional recovery. However, the potential benefits in proprioceptive reinnervation and the quality of ligamentization remain hypothetical and were not assessed objectively. In children, whose biological response is greater, maximizing this potential is a logical step. Preserving the tibial remnant may also offer important rehabilitation benefits, as the loss of mechanoreceptors is a major concern in reconstruction and the remnant serves as a source of proprioceptive reinnervation.⁵

From a biomechanical perspective, although current trends favor anatomical reconstruction,⁷ the Micheli–Kocher technique prioritizes physeal safety over precise restoration of femoral anatomy. Creating the opening in the superolateral corner gives the remnant an even greater role: it acts as a hammock or natural scaffold, helping the reconstructed ligament follow an orientation closer to that of the native tissue and preventing a horizontal

course. This makes soft tissue integration even more critical. The proposed synergy extends beyond biology, as remnant preservation also helps control rotation more effectively than reconstruction alone.⁵ However, these theoretical benefits must be distinguished from the observed clinical outcomes, which are limited to mechanical stability and range of motion.

This technique requires careful patient selection. As Pascual-Leone et al. emphasize, pediatric surgical techniques must be tailored to each patient's individual characteristics.⁶ Not all patients are suitable candidates. Attempting to preserve a fibrotic or insufficient remnant, or one that obstructs visualization, may lead to complications such as cyclops syndrome or extension deficits. As Colombet cautions, surgeons must always weigh the intraoperative risks and benefits of augmentation to avoid compromising joint mechanics.⁸

In conclusion, this modification of the Micheli-Kocher technique maintains the established safety of extraphyseal reconstruction while preserving the remnant's biological potential by passing the graft through a superolateral opening. In this single case report, the technique was feasible and safe, although prospective studies with larger samples are needed to determine whether it offers clinical advantages over the conventional technique.

This study has the limitations inherent to a single case report (level V evidence), which prevent generalization of the findings or statistical comparison with the standard technique. The absence of validated functional scores and objective proprioception testing also limits assessment of the actual biological benefit of the technique described.

Conflicts of interest: The authors declare no conflicts of interest.

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