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ADVANCES IN ACL RECONSTRUCTION: COMBINED INTRA- AND EXTRA-ARTICULAR APPROACH, BIOLOGICAL FOUNDATIONS, AND LONG-TERM OUTCOMES

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SUMMARY

Introduction: *anterior cruciate ligament (ACL) injuries cause rotational instability and can affect return to sports. Combined intra- and extra-articular reconstruction, including the anterolateral ligament (ALL), has emerged as an alternative to improve knee stability.*

Objective: *to detail the current evidence on ACL reconstruction, considering its relationship with the ALL, rotational stability, surgical management, and return to physical activity.*

Methodology: *twenty-five articles were analyzed, including reviews, original studies, and clinical cases, of which 13 were used for their relevance. The sources of information were PubMed, Google Scholar, and Cochrane, using terms in Spanish, Portuguese, and English related to ACL, LLA, and combined reconstruction.*

Results: *combined ACL and LLA reconstruction showed greater rotational stability as measured by the pivot shift test, with no significant differences in complications, pain, joint function, or graft survival compared to isolated reconstruction.*

Conclusions: *combined intra- and extra-articular reconstruction improves the rotational stability of the knee, promoting a safer return to sport, and is especially recommended in patients at risk of residual instability.*

KEYWORDS: *Anterior Cruciate Ligament; Anterolateral Ligament; Combined Reconstruction; Rotational Stability; Knee; Return To Sport.*

INTRODUCTION

The anterior cruciate ligament (ACL) is a specialized connective tissue structure located in the knee joint that connects the tibia to the femur. It is mainly composed of collagen fibers, which account for approximately 70% of its dry weight. ACL deficiency not only causes episodes of joint instability, but also alters knee mechanics, potentially leading to degenerative changes and associated meniscal injuries in up to 50% of cases. Anatomical variation of the distal intercondylar groove of the femur appears to be associated with an increased risk of ACL injury. Clinical evaluation, including tests such as Lachman and anterior drawer, combined with imaging studies such as magnetic resonance imaging, allows for an accurate diagnosis. The decision on whether to use conservative or surgical management depends on multiple factors, including age, activity level, the presence of concomitant injuries, and the severity of instability. Surgical reconstruction of the ACL has proven to be a highly effective technique, although it is not without limitations, and is accompanied by rehabilitation programs aimed at restoring knee function, strength, and proprioception(1).

In recent years, anterolateral reinforcement (ALL) has emerged as a complementary technique in ACL reconstruction, aimed at improving the rotational stability of the knee. This procedure involves reconstructing the anterolateral ligament, which acts as a lateral and rotational stabilizer, and is usually performed using autologous grafts or allografts fixed in the anterolateral region with screws or anchors. It is mainly indicated in patients at high risk of re-rupture, such as elite athletes, individuals with ligamentous hyperlaxity or knees with varus deformities, as well as in cases of revision surgery. Biomechanical and clinical studies have shown that the addition of LLA to ACL reconstruction significantly reduces rotational instability and re-rupture rates, acting as a complement that improves the overall stability of the joint without replacing the primary function of the ACL(2).

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METHODOLOGY

This review analyzed a total of 25 articles, including review articles and original articles, as well as case studies and clinical trials, of which 13 bibliographies were used because the information compiled in the other studies was not relevant enough to be included in this work.

The sources of information were the Cochrane Library, PubMed, and Google Scholar. The terms used to search for information in Spanish, Portuguese, and English were: "anterior cruciate ligament," "ACL reconstruction," "anterolateral ligament," "combined intra- and extra-articular reconstruction," "rotational stability ACL," "anterolateral ligament reconstruction," and "knee instability."

The selected bibliography covers topics related to the biomechanics of the anterior cruciate ligament and the anterolateral ligament, surgical reconstruction techniques, functional outcomes, and rotational stability after surgery. In addition, aspects of etiology, clinical presentation, diagnostic imaging, functional assessment, and surgical and rehabilitative management of ACL injuries and their reconstruction associated with the LLA are analyzed.

DEVELOPMENT

Multiple techniques have been developed for anterior cruciate ligament (ACL) reconstruction, with hamstring tendons (gracilis and semitendinosus) being an interesting alternative to the patellar tendon due to their lower invasiveness, ease of procurement, and biomechanical characteristics similar to those of the ACL. The technique described combines intra-articular and extra-articular reconstruction, leaving the distal insertion of the tendons intact, fixing them in a tibial tunnel and in a posterolateral groove of the femur, and passing the extra-articular portion under the fascia over the lateral collateral ligament, which provides additional rotational stability. There are studies with evidence from a series of 40 active patients, with a minimum follow-up of 2 years, which observed highly satisfactory functional results: 92.5% of knees were normal or almost normal according to IKDC, mean Lysholm score of 95, mean laxity difference of 2.1 mm measured by KT-2000, and resumption of sports in 90% of cases, confirming the efficacy and safety of this technique(2).

Figure 1. Anteroposterior radiograph of the right knee after ACL reconstruction with combined intra- and extra-articular graft.



Source: Authors.

The anterolateral reinforcement technique (ALL) is used as a complement to ACL reconstruction to improve the rotational stability of the knee, especially in cases of residual instability or chronic injuries. It consists of passing a strip of hamstring tendon graft through bone tunnels, fixing it to both the tibia and femur, maintaining adequate tension to control internal rotation and anterolateral laxity. The extra-articular portion of the graft reinforces the reconstructed ligament and allows for the correction of any associated instability, while the over-the-top arrangement reduces surgical trauma and facilitates graft isometry. This intra-articular and extra-articular combination has been shown to improve functional outcomes and decrease the recurrence of instability, being especially useful in high-level athletes and patients with complex injuries(2).

The anterolateral ligament (ALL) is a consistent and clearly distinguishable ligamentous structure in the human knee. It originates at the lateral femoral epicondyle, slightly anterior to the lateral collateral ligament (LCL), and runs obliquely toward the anterolateral aspect of the tibia, inserting between Gerdy's tubercle and the head of the fibula, with fibers partially enveloping the lateral meniscus. Its path separates it from the iliotibial band and the joint capsule, although it maintains a close relationship with the LCL, forming the so-called lateral collateral ligament complex (LCLC). This anatomical arrangement suggests its function as a stabilizer of tibial internal rotation and its involvement in preventing the pivot shift phenomenon in knees with ACL deficiency, confirming the importance of the LLA in the anterolateral stability of the knee(3).

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Anterior cruciate ligament (ACL) reconstruction has evolved over more than a century, beginning with the first attempts in the 1920s to restore joint stability. Various pioneers, such as John Marshall and James Horne, proposed techniques for fixing tendon grafts to the lateral femoral condyle, while Henry Milch and Ellison suggested extra-articular procedures to control tibial rotation. The "Over-the-Top" technique, developed more than 25 years ago at the Rizzoli Institute by Marcacci and Zaffagnini, combines intra-articular reconstruction with extra-articular lateral tenodesis, using hamstring grafts while preserving the tibial insertion. This combination seeks to restore the native kinematics of the knee, reducing residual rotational instability, particularly in cases with anterior lateral ligament (ALL) involvement, highlighting the relevance of additional lateral procedures to improve surgical outcomes(4).

The "Over-the-Top" technique begins with diagnostic arthroscopy and preparation of the hamstrings, preserving their tibial insertion. A tibial tunnel is created, followed by a lateral incision to pass the graft through the joint capsule and fix it in position "over the top" of the lateral femoral condyle. The remaining portion of the graft is channeled deep into the iliotibial band and fixed below Gerdy's tubercle, completing the lateral plasty. This biological approach preserves the vascularization and innervation of the Pes Anserinus, promoting tendon-bone integration and early graft maturation, which translates into superior mechanical properties and reduced risk of avascular necrosis compared to free grafts(4).

Various biomechanical studies have shown that the intra- and extra-articular combination effectively reduces anterior-posterior translation and internal rotation of the tibia, surpassing isolated intra-articular single- or double-beam techniques. The incidence of combined LLA and ACL injury, reported in 30-40% of cases, justifies the use of lateral plasty even in primary reconstructions. Long-term clinical results, with follow-ups of up to 24 years, show high rates of normal or near-normal knees (86-94%), low incidence of residual instability, minimal lateral arthritic progression, and successful return to sports, demonstrating the safety and efficacy of the "Over-the-Top" technique combined with lateral plasty, even in special populations such as adolescents, professional athletes, and patients over 50 years of age(2,4).

Figure 2. Lateral radiograph of the right knee after ACL reconstruction with combined intra- and extra-articular graft.



Source: Authors.

The "Over-the-Top" technique with lateral plasty has proven to be versatile and safe when combined with other complex surgical procedures. It has been used successfully in failed ACL revisions, preventing femoral tunnel enlargement and facilitating the use of Achilles tendon allografts when hamstrings have already been used. In skeletally immature patients and adolescents, physeal preservation and lateral tenodesis have shown low revision rates and satisfactory return to sports. In professional athletes, the technique has allowed them to return to competition in an average of 6-8 months with excellent joint stability. It has also been applied in patients over 50 years of age, in combination with varus osteotomies and meniscal allograft transplants, as well as in selected cases of unicompartmental arthroplasty, achieving functional improvements, knee stability, and a low incidence of perioperative complications(4,5).

Various research groups have provided additional evidence on the effectiveness of combining intra-articular reconstruction with extra-articular procedures in preventing residual rotational instability of the ACL. Recent studies have shown that the addition of lateral techniques, using hamstring or iliotibial tract grafts, significantly improves stability in dynamic functional tests, such as pivot shift, and reduces the recurrence rate of instability in high-level athletes. In addition, these authors highlight the importance of customizing reconstruction according to individual factors, such as tibial geometry, preoperative laxity, and sports activity, which allows for optimized functional outcomes and safe return to sports without significantly increasing the risk of postoperative complications(6,7).

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Maestro et al. demonstrated that up to 27% of ACL reconstructions show a residual positive pivot-shift sign, reflecting rotational instability that can affect return to sport and increase the risk of further injury. The addition of anterolateral ligament (ALL) reconstruction to ACL reconstruction significantly improved rotational stability as assessed by the pivot-shift test, without generating relevant differences in the Lachman test, IKDC scores, pain, complications, or graft survival. These findings suggest that the combined ACL+ALL technique offers specific benefits in controlling rotation, being particularly useful in athletes or physically active individuals, without compromising overall knee function or the safety of the procedure(8).

RESULTS

Comparative studies between isolated anterior cruciate ligament (ACL) reconstructions and those combined with anterolateral reconstruction or tenodesis show that the mixed technique provides greater rotational stability of the knee, evidenced by a significant reduction in the pivot shift test. However, no relevant differences were observed in anteroposterior stability (assessed using the Lachman test), functional scores (IKDC and Lysholm), pain intensity, or complication rates.

Patients treated with combined techniques showed a lower incidence of graft failure and greater confidence in the knee during sports practice, although return-to-sport times were similar between the two groups. Overall, the results support that ACL reconstruction associated with anterolateral reinforcement offers a biomechanical advantage in rotational stability without increasing the risk of complications or affecting graft survival.

DISCUSSION

The findings of this review are consistent with the growing evidence supporting combined anterior cruciate ligament (ACL) and anterolateral ligament (ALL) reconstruction as a biomechanically superior alternative to isolated ACL reconstruction. Several authors have demonstrated that the addition of extra-articular reinforcement allows for more effective control of anterior tibial translation and internal rotation, significantly reducing the incidence of positive pivot shift and, therefore, the subjective feeling of instability reported by patients.

Although overall functional differences—in parameters such as the IKDC, Lysholm, or Tegner scales—do not always reach statistical significance, optimized rotational control offers particularly notable advantages in high-performance athletes and in patients with hyperlaxity or previous graft failures. This biomechanical benefit could translate into a lower rate of long-term re-ruptures, although graft survival results still require prolonged follow-up and multicenter trials to confirm this trend.

The study by Maestro et al. reinforces this perspective, demonstrating that the combined ACL+LLA technique provides greater rotational stability without increasing surgical complications or compromising graft survival. These results are consistent with previous reports that highlight the importance of anterolateral control to avoid intra-articular graft overload and improve safe return to sports activity.

On the other hand, the potential risks associated with the combined procedure must be considered, such as stiffness or overtightening of the extra-articular construct, which can alter the physiological kinematics of the knee. Therefore, correct patient selection, anatomical positioning of the bone tunnels, and adequate graft tension are determining factors in optimizing results and preventing complications.

In summary, current evidence suggests that combined anatomical reconstruction of the ACL and LLA represents a technical evolution with solid biomechanical foundations, particularly indicated in scenarios of high functional demand or risk of rotational failure. However, broader consensus on the precise indications and standardization of the surgical technique is required to consolidate its application in routine clinical practice.

The findings described are consistent with the results reported by other authors, who emphasize that anterolateral reinforcement—whether through LLA reconstruction or modified extra-articular tenodesis—contributes significantly to rotational stability without compromising mobility or increasing the complication rate. In multicenter studies, a substantial reduction in the incidence of graft failure and pivot shift sign was observed when combined reconstruction was used versus the isolated technique. This evidence supports the hypothesis that the double anatomical approach (ACL + LLA) not only improves joint kinematics but could also represent a paradigm shift in reconstructive knee surgery, especially in young patients, athletes, or those at high risk of residual rotational instability(9–13).

CONCLUSIONS

Combined ACL and LLA reconstruction represents a technical evolution with solid anatomical and biomechanical foundations. This approach allows for the restoration of both anterior-posterior and rotational stability of the knee, reducing the risk of residual pivot shift and improving medium- and long-term functional outcomes. Current studies show that this technique is safe, reproducible, and effective, with no increase in complications or loss of mobility.

In summary, anterolateral reinforcement associated with anatomical ACL reconstruction should be considered a valid alternative in young patients, athletes, or those with high functional demands, in whom rotational stability is crucial for preventing new injuries and optimizing return to sports. Multicenter clinical trials with long-term follow-up are recommended to confirm the long-term benefits and establish precise criteria for indication.

BIBLIOGRAPHY

1. *Diana Carolina Martínez Pesántez, Bryam Esteban Coello García, Daniela Elizabeth Galarza Ulloa, Juan Francisco Vidal Moreno, Fabiana Domenica Palacios Rivera, Karina Noemí Contreras García, et al. ANTERIOR CRUCIATE LIGAMENT, DESCRIPTION, RUPTURE AND TREATMENT. EPRA Int J Multidiscip Res IJMR. 2023 Jan 17;137–49.*

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2. *Zaffagnini S, Marcheggiani Muccioli GM, Grassi A, Roberti Di Sarsina T, Raggi F, Signorelli C, et al. Over-the-top ACL Reconstruction Plus Extra-articular Lateral Tenodesis With Hamstring Tendon Grafts: Prospective Evaluation With 20-Year Minimum Follow-up. Am J Sports Med. 2017 Dec;45(14):3233–42.*
3. *Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J. Anatomy of the anterolateral ligament of the knee. J Anat. 2013 Oct;223(4):321–8.*
4. *Zaffagnini S, Lucidi GA, Macchiarola L, Agostinone P, Neri MP, Marcacci M, et al. The 25-year experience of over-the-top ACL reconstruction plus extra-articular lateral tenodesis with hamstring tendon grafts: the story so far. J Exp Orthop. 2023 Jan;10(1):36.*
5. *Marcacci M, Zaffagnini S, Iacono F, Neri MP, Loreti I, Petitto A. Arthroscopic intra- and extra-articular anterior cruciate ligament reconstruction with gracilis and semitendinosus tendons. Knee Surg Sports Traumatol Arthrosc. 1998 Apr;6(2):68–75.*
6. *Song G yang, Hong L, Zhang H, Zhang J, Li Y, Feng H. Clinical Outcomes of Combined Lateral Extra-articular Tenodesis and Intra-articular Anterior Cruciate Ligament Reconstruction in Addressing High-Grade Pivot-Shift Phenomenon. Arthrosc J Arthrosc Relat Surg. 2016 May;32(5):898–905.*
7. *Guarino A, Farinelli L, Iacono V, Screpis D, Piovan G, Rizzo M, et al. Lateral extra-articular tenodesis and anterior cruciate ligament reconstruction in young patients: clinical results and return to sport. Orthop Rev [Internet]. 2022 Apr 25 [cited 2025 Oct 24];14(5). Available from: https://orthopedicreviews.openmedicalpublishing.org/article/33696-lateral-extra-articular-tenodesis-and-anterior-cruciate-ligament-reconstruction-in-young-patients-clinical-results-and-return-to-sport*
8. *Maestro A, Rodríguez N, Pipa I, Toyos C, Lanuza L, Machado F, et al. Influence of Extra-Articular Augmentation on Clinical Outcomes and Survival in Patients Undergoing Anterior Cruciate Ligament Reconstruction: A Pseudorandomized Study. Medicina (Mex). 2025 Jan 14;61(1):116.*
9. *Kawanishi Y, Kobayashi M, Yasuma S, Fukushima H, Kato J, Murase A, et al. Anterolateral ligament reconstruction in addition to primary double-bundle anterior cruciate ligament reconstruction for grade 3 pivot shift improves residual knee instability during surgery. J Exp Orthop. 2021 Jan;8(1):51.*
10. *Helito CP, Sobrado MF, Giglio PN, Bonadio MB, Pécora JR, Camanho GL, et al. Combined Reconstruction of the Anterolateral Ligament in Patients With Anterior Cruciate Ligament Injury and Ligamentous Hyperlaxity Leads to Better Clinical Stability and a Lower Failure Rate Than Isolated Anterior Cruciate Ligament Reconstruction. Arthrosc J Arthrosc Relat Surg. 2019 Sept;35(9):2648–54.*
11. *Delaloye JR, Murar J, Koch PP, Sonnery-Cottet B. Combined anterior cruciate ligament and anterolateral ligament lesions: from anatomy to clinical results. Ann Jt. 2018 Oct;3:82–82.*
12. *Saithna A, Thaunat M, Delaloye JR, Ouanezar H, Fayard JM, Sonnery-Cottet B. Combined ACL and Anterolateral Ligament Reconstruction. JBJS Essent Surg Tech. 2018 Mar 28;8(1):e2.*
13. *Getgood AM, Bryant D, Litchfield RB, McCormack RG, Heard M, MacDonald PB, et al. Lateral Extra-Articular Tenodesis Reduces Failure of Hamstring Tendon Autograft ACL Reconstruction -Two Year Outcomes from the STABILITY Study Randomized Clinical Trial. Orthop J Sports Med. 2019 July 1;7(7_suppl5):2325967119S00280.*

Conflict of Interest Statement
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