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IMPROVEMENT OF ROTATIONAL KNEE STABILITY USING LATERAL EXTRA-ARTICULAR TENODESIS AND ANTEROLATERAL LIGAMENT RECONSTRUCTION: INDICATIONS, COMPLICATIONS, AND COMPARISON OF TECHNIQUES — A REVIEW OF THE LITERATURE

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ABSTRACT

The anterior cruciate ligament (ACL) is one of the most frequently injured structures of the knee. To restore joint function, ACL reconstruction surgery is commonly performed. However, despite successful reconstruction, some patients fail to regain full function due to residual rotational instability. Procedures aimed at improving rotational stability include anterolateral ligament reconstruction (ALLR) and lateral extra-articular tenodesis (LET). This article reviews the anatomy of the ACL and the anterolateral complex. The techniques of ALLR and LET are described, and the two methods are compared. Indications, complications, clinical outcomes, and potential long-term effects of these procedures are also discussed.

KEYWORDS

ACL, ACLR, ALLR, LET, Comparison

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1. Introduction

The anterior cruciate ligament (ACL) is a structural component of the knee that is frequently prone to injury. According to available data, it accounts for approximately 50% of all knee injuries. This is particularly relevant in women and young, active individuals. Furthermore, as many as 400,000 reconstructive surgeries are performed annually in the United States alone [3].

Anterior cruciate ligament reconstruction (ACLR) is performed arthroscopically. Various methods are available for obtaining a graft, including the semitendinosus and gracilis tendons, the bone–patellar tendon–bone technique, or the quadriceps tendon [4].

Although the long-term outcomes of ACLR are generally satisfactory, the rotational stability of the knee is not fully restored, with as many as 25% to 30% of patients continuing to experience this issue. Moreover, the rate of return to pre-injury sports participation ranges from 44% to 72%, which is considered suboptimal [5].

The resulting rotational instability increases the risk of meniscal and cartilage injuries and contributes to the progression of degenerative changes within the joint [11]. To mitigate these risks, techniques aimed at improving stabilization—such as more lateral femoral tunnel placement or the addition of a posterolateral bundle—have been employed; however, these methods have not achieved the desired outcomes [5][12].

The discovery of the role of the anterolateral structures of the knee, such as the iliotibial band and the anterolateral joint capsule and ligament, which act synergistically with the ACL, has led to the development of additional lateral stabilization techniques, namely lateral extra-articular tenodesis (LET) and anterolateral ligament reconstruction (ALLR). These techniques enable the reduction of rotational instability and have also been associated with a decreased rate of ACL graft re-injury [13].

This article aims to present the methods of additional stabilization in ACL injury, including lateral extra-articular tenodesis and anterolateral ligament reconstruction. The surgical techniques for performing these procedures are described, along with the indications for their use and potential complications. The two methods are then compared, with the strengths and limitations of each identified to tailor the treatment process as closely as possible to the individual needs of the patient.

2. Anatomy and Biomechanics

The anterior cruciate ligament is located between the medial part of the lateral femoral condyle and the anterior part of the tibial plateau. It consists of two bundles: the anteromedial (AM) and posterolateral (PL) bundles. The names of these bundles derive from the location of their distal attachment on the tibia [1][2]. The AM bundle is primarily responsible for limiting anterior translation of the tibia. The fibers of this bundle become tense during knee flexion and are optimally positioned to perform this function. The PL bundle, by contrast, plays a role in limiting internal rotation of the tibia; however, due to its anatomical orientation and fiber alignment, it does not provide sufficient stabilization on its own. This highlights the importance of the anterolateral complex (ALC) [16].

The anatomy of the anterolateral complex of the knee joint is more intricate, and there is no complete consensus in the literature regarding its individual components. The ALC comprises a group of structures located on the lateral side of the knee, extending from the proximal Kaplan fibers to Gerdy's tubercle. The superficial layer of the iliotibial band (ITB) runs anteriorly toward the patella and terminates at Gerdy's tubercle, with posterior connections to the fascia of the biceps femoris muscle. The middle layer of the ITB, characterized by its obliquely arranged fibers, has also been described [15]. The deep layer lies beneath the middle layer and attaches slightly posterior to Gerdy's tubercle [14].

Within the deep layer are the Kaplan fibers, which connect the superficial layer of the ITB to the femoral epiphysis in a transverse orientation. These fibers can be subdivided into proximal and distal bundles [17]. They are reinforced by the capsulo-osseous layer, which links to the fascia of the gastrocnemius muscle and the biceps femoris tendon, forming the deepest layer of the ITB [20]. The ALC also includes the anterolateral part of the joint capsule and the anterolateral ligament (ALL). The ALL is defined as a capsular structure of variable size and thickness among individuals. It attaches proximally and posteriorly to the lateral femoral epicondyle, adjacent to the lateral collateral ligament (LCL), crosses over it, and attaches distally to the posterior portion of Gerdy's tubercle on the tibia, with connections to the lateral meniscus.

The ALC functions as a cohesive unit to provide rotational stability in conjunction with the ACL. Injury to both the ACL and the ALC significantly increases rotational instability, whereas isolated injuries to either structure may not necessarily result in clinical instability if the other structure remains intact [25].

3. Anterolateral Ligament Reconstruction

Anterolateral ligament reconstruction involves replacing the damaged ligament with a graft to restore knee stability and function. This procedure can be performed arthroscopically, through minimally invasive techniques, and in combination with ACLR. The aim is to eliminate rotational instability and augment ACL function. The procedure can be carried out in various ways, including anatomical ALL reconstruction, often using autografts from the patient [18]; augmentation combined with ACL reconstruction, where both ligaments are reconstructed simultaneously, often sharing the same graft [19]; isometric ALL reconstruction, ensuring constant graft tension throughout knee motion [21]; the all-onlay technique, in which the graft is fixed on the surface of the femur for extra-articular reconstruction [22]; and the all-inside technique, which uses tibial and femoral tunnels for intra-articular reconstruction [23]. Combined ACL–ALL reconstruction can be performed using the same or separate grafts for each ligament [24]. Semitendinosus and gracilis tendons are commonly used as graft sources [18].

The femoral tunnel for ALLR is generally created proximal and posterior to the lateral femoral epicondyle, while the tibial tunnel is positioned midway between the fibular head and Gerdy's tubercle. In some cases, two tibial tunnels are created to better replicate the anatomical footprint of the ALL. The femoral tunnel is positioned with the knee in full extension or slight flexion. The graft is tensioned near full extension to control axial displacement and loosened at 90° flexion to permit physiological internal rotation [14].

Graft tensioning plays a critical role in restoring normal knee kinematics. Studies have shown that a tension of approximately 20 N at full extension restores normal knee biomechanics, whereas higher tensions (e.g., 88 N at 70° flexion) excessively restrict internal rotation [29][30]. The optimal tension is therefore considered to be around 20 N [32].

One of the challenges of ALLR is the risk of femoral tunnel convergence between the ACL and ALL tunnels. Using an outside-in technique for ACL femoral tunnel creation allows better control of the tunnel orientation on the lateral femoral cortex and reduces the risk of convergence. In contrast, the inside-out technique provides less predictability regarding tunnel exit location [33][34].

While no standardized guidelines currently exist for ALLR indications, the procedure is recommended for patients at high risk of ACL graft failure [14]. Complications may include infection (0.32% to 1.8%), persistent pain and swelling, hemarthrosis requiring drainage, deep vein thrombosis, nerve injury, complex regional pain syndrome, graft failure, excessive scar formation leading to stiffness, patellar fracture (in cases using patellar tendon grafts), and recurrent instability [35][36][37].

4. Lateral Extra-articular Tenodesis

Lateral extra-articular tenodesis is a well-established procedure first described by Lemaire in 1967 [26]. ACLR alone may not provide sufficient rotational stability, predisposing patients to chronic knee instability, reduced return-to-sport rates, ACL re-injury, and earlier onset of degenerative changes [27]. Biomechanical studies have demonstrated that combining ACLR with LET offers superior rotational stability compared to isolated ACLR [28]. Clinical studies have further shown that LET reduces the risk of ACL graft failure by 30% to 58% in high-risk groups such as athletes and individuals with high-grade pivot shift [31].

Numerous LET techniques exist, varying in graft type and fixation method. The modified Lemaire technique is among the most commonly employed. It uses a 10–12 mm wide, 7–8 cm long ITB graft, preserving its attachment at Gerdy's tubercle. The proximal portion is dissected approximately 2 cm above the lateral femoral epicondyle, and the free end is sutured using a Krakow suture. The graft is passed deep to the LCL using a shuttle suture loop, optimally controlling internal rotation during both flexion and extension while preventing graft dislocation over the condyle. Fixation is performed near the LCL attachment, approximately 1 cm proximal and posterior to the original LCL insertion on the femoral condyle. A tunnel is drilled in an anterior–proximal direction to avoid convergence with the ACL tunnel, and fixation is secured with the knee at 70°–90° flexion and neutral rotation [31].

Indications for LET, as described by Getgood et al., include return to pivoting sports, high-grade pivot shift (grade 2 or higher), generalized ligamentous laxity, and knee hyperextension (recurvatum >10°) [42].

Zabrzyński et al. recently conducted a systematic review in which they noted that the most common indications for LET are meniscal surgery, sports activity, and grade 2 and 3 pivoting. Other indications may include Segond fracture, chronic anterior cruciate ligament lesion, radiographic lateral femoral notch sign, and lateral coronal plane laxity.[43]

Complications of LET include removal or irritation of LET material fixation, hematoma over the LET site, and pain over the LET site. The total complication rate is estimated at 4.2% according to Zabrzyński et al. [40] Excessive tension of the lateral complex is also possible, resulting in faster degenerative changes. However, Devitt et al. showed in their study that the evidence for the presence of degenerative changes is insufficient and further long-term studies are necessary to confirm this phenomenon. [41]

Table 1. Comparison of ALLR and LET

Category	ALLR	LET
Type of Graft	Semitendinosus or gracilis tendon	Iliotibial band 10–12 mm wide, 7–8 cm long
Initial Attachment Site	8 mm proximal and 4 mm posterior to lateral femoral epicondyle	1 cm posterior and 1 cm proximal to fibular collateral ligament
Final Attachment Site	5–10 mm below joint line Midpoint between Gerdy's tubercle and fibular head Two tibial tunnels may be used	Distal attachment intact at Gerdy's tubercle Longer lever arm may increase joint restriction
Graft Fixation	Fixed in full or near-full extension Neutral rotation Tension: ~20N	Fixed at 70–90° flexion Neutral rotation Tension: ~20N
Technical Considerations	Risk of tunnel collision with ACLR if anterior proximal direction not maintained	Excessive tension may increase stiffness and cause early osteoarthritis
Clinical Effects	Increased rotational stability Reduced ACL re-injury risk Reduced residual laxity	Increased rotational stability Reduced ACL re-injury risk Reduced residual laxity

The Table 1. shows a comparison of anterolateral ligament reconstruction - ALLR with extra-articular lateral tenodesis - LET. ACL - anterior cruciate ligament, ACLR - anterior cruciate ligament reconstruction.

5. Conclusions

Additional stabilization techniques, namely anterolateral ligament reconstruction and lateral extra-articular tenodesis, are increasingly used in conjunction with ACL reconstruction. Evidence suggests that these methods significantly enhance rotational stability, reduce the risk of ACL graft failure, and minimize residual laxity compared to isolated ACL reconstruction. While ALLR and LET differ in graft selection and fixation sites, their clinical outcomes appear comparable. To establish optimal patient selection criteria and assess potential long-term risks, particularly concerning joint degeneration, further multicenter clinical trials and long-term follow-up studies are warranted.

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List of abbreviations:
ACL - Anterior Cruciate Ligament, ALLR - Anterolateral Ligament Reconstruction, LET - Lateral Extra-articular Tenodesis, ACLR - Anterior Cruciate Ligament Reconstruction, AM – Anteromedial, PL – Posterolateral, ALC - Anterolateral Complex, ITB - Iliotibial Band, ALL - Anterolateral Ligament, LCL - Lateral Collateral Ligament.

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