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Kaplan fibers of iliotibial band: a comprehensive review of current literature

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- This review highlights the pivotal role of Kaplan fibers (KFs) in knee stability, particularly in the anterolateral aspect. Studies reveal their complex anatomy with varying attachments to the distal femur, demonstrating a significant impact on knee joint mechanics across different populations.
- Investigations into the biomechanics of KFs show their crucial role in maintaining rotational stability of the knee, especially during rotational movements. Their synergistic function with other knee structures, like the anterolateral ligament, is emphasized, underscoring their importance in knee integrity and function.
- MRI emerges as a key tool in detecting KFs, with varying visibility and prevalence of injuries. The review discusses the development of MRI criteria for accurate diagnosis, highlighting the need for further research to refine these criteria and understand the interplay between KF injuries, anterior cruciate ligament (ACL) ruptures, and associated knee pathologies.
- The review covers various lateral extra-articular tenodesis (LET) techniques used to address residual laxity and instability following ACL reconstruction. Among them, the modified Lemaire technique, which resembles the anatomical and functional characteristics of distal KFs, shows effectiveness in reducing internal rotation and residual laxity.
- The review emphasizes the need for further research to understand the healing dynamics of KF injuries and the efficacy of different LET techniques. It suggests that a comprehensive approach, considering both biomechanical and clinical aspects, is crucial for advancing knee joint health and rehabilitation.

Keywords: Anterolateral knee; iliotibial band; Kaplan fibers; knee joint stability

Introduction

Among the myriad of anatomical structures contributing to knee function, the iliotibial band (ITB) and its intrinsic Kaplan fibers (KFs) stand as crucial components in maintaining lateral knee stability (1). The KFs, named after the orthopedic surgeon who first elucidated their significance, are fine fibrous bands extending from the ITB to the lateral intermuscular septum and the distal femur (2). Over the years, their role in knee biomechanics has become a focus of increasing scrutiny in orthopedic research, especially in the context of sports medicine (3).

The exploration of KFs' biomechanics and their interplay with other knee structures is essential for a deeper

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understanding of knee joint stability, particularly in the anterolateral aspect (4). Furthermore, these insights are pivotal in advancing surgical techniques aimed at restoring knee function following an injury, particularly in the setting of anterolateral rotatory instability (5, 6).

This comprehensive review summarizes the existing body of literature to provide an understanding of the KFs' biomechanics, their role in knee stability, and their impact on clinical practices. This review offers a substantial contribution to the orthopedic community's collective knowledge, fostering a foundation for future research and clinical advancements in knee joint health and rehabilitation.

Anatomy of KFs

Originating from the deep layer of the ITB, KFs exhibit a unique pattern of attachment to the distal femur, contributing to knee joint stability and function (Figs 1 and 2) (7). Herein, the anatomy of KFs as observed across various studies is outlined.

Godin *et al.* (2017) elucidated the course and attachment points of KFs (7). Two distinct bundles, proximal and distal, were identified. The proximal bundle extends nearly transversely from the undersurface of the superficial ITB to a point on the femur 53.6 mm proximal to the lateral epicondyle. In contrast, the distal bundle follows a more complex path, originating from the superficial ITB and proceeding from a proximal and lateral position to a distal and medial one before anchoring onto the femur 31.4 mm proximal to the lateral epicondyle. Distal KFs were found to be closely associated with the superior lateral genicular artery. Further, the deep fibers of the ITB, including the KFs, extended from the ITB's undersurface, skirting the biceps femoris muscle, to their insertion points on the distal femur.

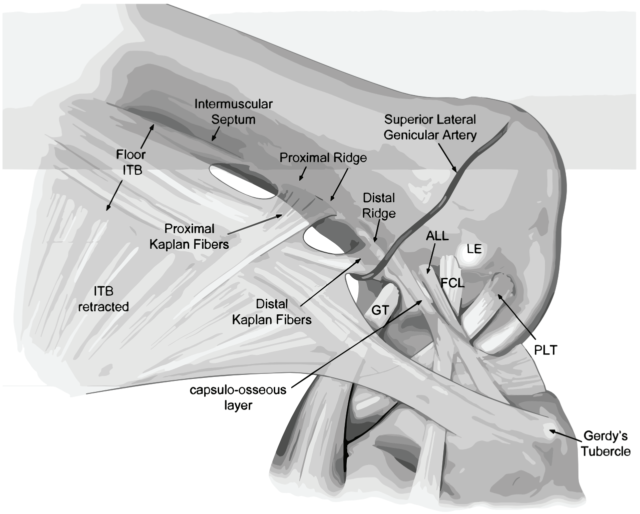

Figure 1

The ITB and associated anatomical structures in the right knee, the superior lateral genicular artery passes anteriorly to the distal KF, ALL, anterolateral ligament; FCL, fibular collateral ligament; GT, lateral gastrocnemius tendon; ITB, iliotibial band; LE, lateral epicondyle; PLT, popliteus tendon. This figure was reproduced from Godin *et al.*'s article: 'A Comprehensive Reanalysis of the Distal Iliotibial Band: Quantitative Anatomy, Radiographic Markers, and Biomechanical Properties.' *Am J Sports Med*. 2017 Sep;45:2595–603 with permission from SAGE Publications under STM Permissions Guidelines (11).

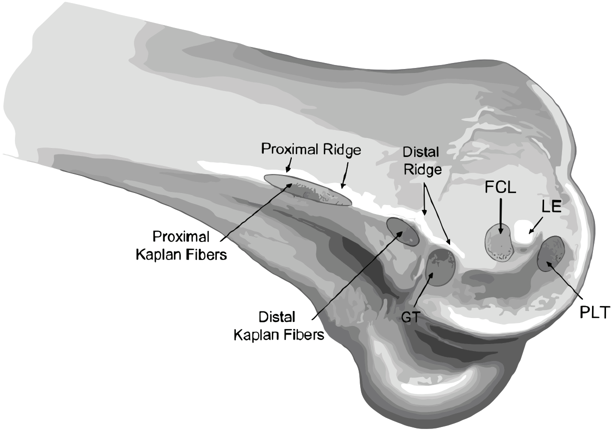

Figure 2

Insertion sites of KF and other structures on the right lateral distal femur, FCL, fibular collateral ligament; GT, lateral gastrocnemius tendon; ITB, iliotibial band; LE, lateral epicondyle; PLT, popliteus tendon. This figure was reproduced from Godin *et al.*'s article: 'A Comprehensive Reanalysis of the Distal Iliotibial Band: Quantitative Anatomy, Radiographic Markers, and Biomechanical Properties.' *Am J Sports Med.* 2017 Sep;45:2595–603 with permission from SAGE Publications under STM Permissions Guidelines (11).

Herbst *et al.* (2017) similarly, characterized the KFs as firm and distinct fiber bundles linking the superficial ITB to the distal femoral metaphysis and condyle (8). These fibers were always found to be in close proximity to branches of the superior lateral genicular artery. Unlike the obliquely aligned fibers of the intermuscular septum, KFs were uniquely recognized by their transverse course from lateral to medial. Their insertion onto the lateral distal femoral metaphysis was confirmed in all dissected specimens, with an additional finding of two thin fiber bundles located more proximally in 80% of the specimens.

The study by Landreau *et al.* (2019) introduced the 'condylar strap' (CS), a distinct anatomic structure found between the femur and lateral gastrocnemius, and the deep surface of the ITB (9). This study was conducted on a Middle Eastern population. This structure, situated between the distal KFs and the epicondyle, was identified in all posterior dissections (Fig. 3). The mean thickness, width, and length of the CS were documented, illuminating its potential role in internal rotation and tenodesis effect on the ITB. An MRI study

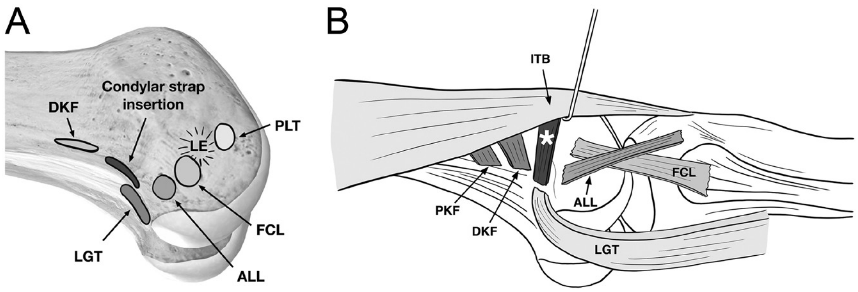

Figure 3

Schematic representation of the distal femur of a right knee demonstrating (A) the insertion sites of the condylar strap (CS) related to the known anatomic structures. (B) The CS (asterisk) connects the deep portion of the iliotibial band (ITB) and the lateral epicondylar area. ALL, anterolateral ligament; DKF, distal Kaplan fibers; FCL, fibular collateral ligament; LE, lateral epicondyle; LGT, lateral gastrocnemius tendon; PKF, proximal Kaplan fibers; PLT, popliteus tendon. This figure was reproduced from Landreau *et al.*'s article: 'Anatomic Study and Reanalysis of the Nomenclature of the Anterolateral Complex of the Knee Focusing on the Distal Iliotibial Band' *Orthopaedic Journal of Sports Medicine*. 2019 Jan 17;7 under license of CC BY-NC-ND 4.0 DEED (1).

also found CS in an Indian population (10). However, no other studies reported on CS until this day.

Sayac *et al.* (2021) similarly, identified two distinct fibrous KFs (11). These fibers, displaying a transverse, latero-medial, and cranio-caudal orientation, extended from the lateral part of the superficial ITB to various points on the distal femoral shaft and lateral femoral condyle. Notably, the superior lateral genicular artery was found in close proximity to the distal KFs (DKF) in 86% of the subjects; and some variations in 14% of the subjects.

Lastly, Raghavan *et al.* (2022) delved into the variations in the distal femoral attachments of the ITB across different ethnic groups (12). Fibrous bands were consistently found in the supracondylar aspect of the femur across all Caucasian knees and most Asian knees. A common double-limb attachment was identified, creating either an 'X' or a 'Y' configuration upon insertion on the distal femur, while a single-limb attachment was noted in a subset of Asian knees.

Overall, KFs exhibit a complex anatomy with consistent yet varying attachments to the distal femur, implicating a nuanced role in knee joint mechanics across different populations.

Biomechanics and function

The biomechanics and functional significance of KFs have been investigated across several studies, shedding light on their role in maintaining knee stability, particularly during rotational movements. Lutz *et al.* (2015) highlighted two anterolateral tissue structures tightened during internal rotation of the tibia at 30° of flexion (4). Among these, the superficial structure comprised of the ITB and KFs was found to act as a ligamentous structure, elucidating its potential to maintain the rotational stability of the knee joint.

In a biomechanical assessment by Godin *et al.* (2017), the attachment strength of KFs to the distal femur was quantified, revealing a substantial load to failure with mean maximum loads of 71.3 N and 170.2 N for the proximal and distal Kaplan bundles respectively (force was at the direction of KFs bundle) (7). This indicated a strong attachment of KFs to the distal femur, supporting their role in rotational knee stability.

Geeslin *et al.* (2018) delved into the impact of sectioning KFs and the anterolateral ligament (ALL) in anterior cruciate ligament (ACL) deficient knees on knee kinematics (13). Their findings demonstrated that sectioning of the KFs led to significantly increased internal rotation (at 15°–90°), especially at higher flexion angles (60°–90°), as compared to ALL sectioning (at 15°–30°). Furthermore, both ALL and KFs were found to restrain internal rotation and contribute to the control of pivot shift and anterior tibial translation in ACL-deficient knees, underscoring the role of KFs in maintaining knee stability at all flexion degrees.

Sayac *et al.* (2021) demonstrated the anatomical distinctiveness of proximal and distal KFs under different rotational conditions (11). Their tensioning in internal rotation suggested a function of controlling rotational knee stability, especially for distal KF, reinforcing the notion of KFs as crucial structures in the lateral compartment of the knee.

The study conducted by Willinger *et al.* (2023) underscored the primary role of the ACL in restraining anterior tibial translation, while the KFs emerged as secondary stabilizers in resisting internal rotation, especially beyond 30° of flexion (14). Specifically, the KFs and anterolateral capsule/ligament (C/ALL) together (aside from ACL) resisted internal rotation, contributing 44% ± 23% and 14% ± 13% respectively at 90° of flexion, indicating a substantial role of KFs in maintaining rotatory stability. Upon sequential sectioning of the structures, it was revealed that a combined injury involving the KFs and C/ALL significantly exacerbated anterolateral rotational instability (in all flexion degrees), whereas isolated injury of either did not have a substantial impact. This indicates a co-dominant relationship between the ALL and KFs in anterolateral stability. In simulated tests that mimic a pivot-shift movement, it was found that cutting the ACL increased rotational instability in the knee from full knee extension to a 40° flexion. This instability became even more pronounced when the lateral structures of the knee were also cut, affecting a broader range of knee flexion (0°–100°). The overarching conclusion drawn from the study was that the anterolateral complex, comprising the ACL, KFs, and C/ALL, acted as a functional unit to provide rotatory stability to the knee. Among these, the KFs were identified as dominant structures in controlling internal rotation in flexion, acting synergistically with the C/ALL.

In summary, KFs are vital structures implicated in the biomechanical stability of the knee, especially in controlling rotational movements. Their synergistic action with other anterolateral structures like the ALL and the robust attachment to the distal femur accentuate their significance in maintaining knee joint integrity and function.

MRI and diagnostic findings

Magnetic resonance imaging (MRI) has emerged as a pivotal tool in the detection and assessment of KFs, particularly in the context of ACL intact knees and associated injuries (Fig. 4). A prospective cohort study underscored the feasibility of detecting KFs through routine MRI sequences. Notably, sagittal views yielded the highest detection rate (96%), while coronal views were less effective with a detection rate of 4% (15). A cadaveric study further explored the utility of three-dimensional MRI (3D MRI), achieving a 100% detection rate for proximal KFs and 90% for DKFs (16). These studies collectively accentuate the diagnostic potential of MRI in evaluating KF anatomy and associated injuries.

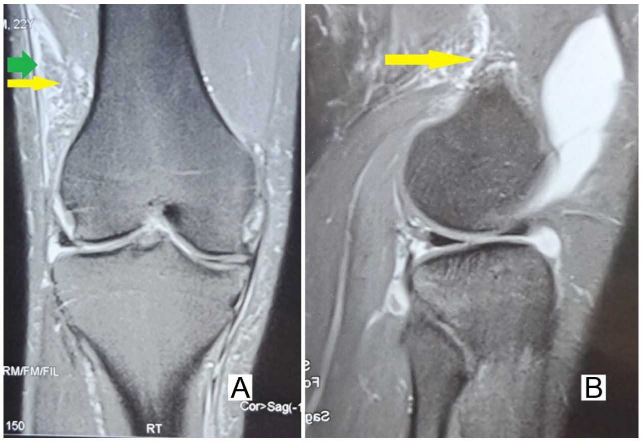

Figure 4

Coronal (A) and sagittal (B) complete tear of the Kaplan fiber complex (yellow arrow) indicated by the wavy appearance and surrounding edema. (green arrow = superficial iliotibial band)

Three studies have pioneered the formulation of MRI criteria for diagnosing KF injuries (17, 18, 19). The criteria by Batty *et al.* are extensively used, entailing both direct and indirect criteria for confirming KF injury diagnosis (18). Van Dyck *et al.* presented graded criteria ranging from grade 0 (normal) to grade 3 (complete tear) (17), while Marom *et al.* introduced a more complex set of criteria for both injured and intact KFs (19). The inter-rater reliability for these criteria has been evaluated across multiple studies, yielding varying kappa values indicative of inconsistent agreement among raters (Table 1) (20, 21, 22, 23, 24, 25, 26).

The visibility of KFs varies, with rates between 76% and 100% across different studies (17, 18, 20, 22, 23, 27, 28, 29). A comparative study between adults and children revealed higher visibility in adults (84.8%) versus children (76.0%) (22). The prevalence of KF injuries, as depicted in MRI, ranges widely between 6.4% and 61% (18, 23). Notably, the interval between ACL rupture and MRI scan significantly impacts the prevalence rates, with a decline observed in patients scanned after 90 days post-ACL rupture (18, 26, 29). However, a clinical study found that the MRI evidence of KF injuries within 60 days of injury will not impact the overall outcomes of ACLR (28). In another study, they also found that MRI evidence of KF injuries was not associated with a higher-grade pivot shift (27). In summation, the observed trends in MRI scans indicate a potential healing trajectory for KF injuries over time. Particularly, the diminishing prevalence of KF injuries in scans conducted beyond 90 days post-ACL rupture hints at a natural healing process. Most of these observed injuries in MRI are probably low-grade injuries and are due to edema at the KF site, and they seem to improve as time passes after the injury. This nuanced understanding underscores the need for further research to directly evaluate the dynamics of KF injuries over time.

Associated injuries

Associations have been noted between KF injuries and lateral meniscal injury, collateral ligament injury, ALL injury, and bone marrow edema (17, 20, 23, 27, 30). Conversely, no significant correlations were reported in some studies between KF injuries and meniscal tears, Segond fractures, chondral injury, bone contusions, or ligamentous injuries (17, 18, 21, 22, 24, 26, 27). The prevalence of KF injuries and ALL injuries showcases notable discrepancies across studies examining ACL injuries (Table 2). Most studies found no significant correlations between ALL injuries and KF injuries, suggesting that these injuries may not be directly related. The biomechanical interactions inherent in an ACL injury event may differentially influence the

Table 1 MRI Studies on Kaplan Fibers.

Study	Cases, *n*	Mean age, years	KF visibility (%)	MRI criteria	KF injury prevalence (%)	Time between ACL rupture and MRI	Other injury correlated with KF injury
Van Dyck *et al.* (17)	69	29	100	Van Dyck	33	< 6 weeks	Significant difference in the frequency and grading between KF, and ALL injuries
Batty *et al.* (18)	161	26	97–100	Batty	24.3–6.4	Before and after 90 days	Injury lateral meniscal injury/ collateral ligaments injury/ posteromedial tibial bone bruising
Marom *et al.* (19)	72	27.65	85–89	Batty	46–60	< 6 weeks	NR
Berthold *et al.* (49)	104	26.8	100	Van Dyck	52.9	< 90 days	Lateral supracondylar/tibial plateau BME
Devitt *et al.* (27)	267	23.6	100	Batty	17.6	< 60 days	Lateral meniscal tears
Devitt *et al.* (28)	122	24.2	100	Batty	26.2	< 60 days	NR
Balendra *et al.* (20)	100	22.3	100	Batty	61	< 21 days	Lateral femoral condyle bone edema/injuries to the superficial MCL, deep MCL/ ramp lesions
Lynch *et al.* (24)	131	27.8	88.5	Van Dyck	38.9	< 90 days	No correlation between KF injury and meniscal tears, or posterolateral tibial bone bruise
Lynch *et al.* (22)	45	13.2	94.6	Batty/Van Dyck	37.7–11.1	< 90 days	No correlation with meniscal tears/Segond fracture
Runer *et al.* (25)	66 + 25	38.4/14.3	84.8–76.0	Runer	18.2–16	NR	NR
Shi *et al.* (26)	51	14.9	88.2	Marom	29.4–35.3	0–182 days	LCL injury/no correlation with MCL or meniscal injury
Watanabe *et al.* (21)	91	25	93.4	Batty	23.5	< 90 days	No correlation between concomitant ligamentous injury, and meniscal injury
Lord *et al.* (29)	89	21	100	Batty	30.3	< 60 days	NR
Chandra *et al.* (10)	134	NR	97.2	Chandra	34	< 90 days	Meniscal tear and bone marrow edema in a classic pivot shift impaction injury pattern

KF, Kaplan fiber; NR, not reported.

KFs and the ALL, accounting for the noted variance in injury prevalence among these structures. This disparity in injury rates underscores the complex nature of ACL trauma. It emphasizes the necessity for more in-depth and nuanced research to elucidate the specific interrelationships and underlying mechanisms governing these injuries, which is pivotal for advancing orthopedic knowledge and treatment strategies.

Table 2 Prevalence of KF injuries and ALL injuries in MRI studies.

Study	KF injuries (%)	ALL injuries (%)	Combined injuries (%)
Van Dyck *et al.* (17)	33	57	7
Batty *et al.* (18)	18	22	2
Balendra *et al.* (20)	58	23	19
Watanabe *et al.* (21)	23	44	10
Runer *et al.* (25)	21	58	12

In clinical examination contexts, current research has not established a significant relationship between MRI-detected KF injuries and the outcomes of pivot-shift tests, anterior drawer tests, and Lachman tests (20, 21, 27). However, all of these MRIs were taken within 60 days of injuries, and it is plausible that a correlation may become more apparent in MRIs performed at later stages. The incidence of KF injuries appears to decrease in MRIs taken at these later stages, whereas more severe injuries probably remain detectable. These persisting injuries could potentially explain the compromised results in clinical tests. Consequently, physicians are advised against relying exclusively on MRI results in the immediate aftermath of an injury for evaluation of KF and ACL injuries. Further investigative efforts are warranted to explore the correlation between delayed MRI findings and clinical examinations. Additionally, no statistically significant associations were identified between KF injuries and patient demographics such as age, sex, laterality, and body mass index (BMI) (26), nor between the type of MRI equipment utilized (3T MRI vs 1.5T MRI) (24).

The diagnostic landscape of KF injuries via MRI remains a complex endeavor, underscored by varying visibility rates, prevalence, and associated findings. Establishing robust, reliable MRI criteria, alongside a deeper understanding of the associated MRI findings and clinical examination correlations, is imperative for enhancing the diagnosis and subsequent management of KF injuries. The inconsistent inter-rater reliability across different MRI criteria highlights a pivotal area for further research, aimed at refining the diagnostic criteria and elucidating the nuanced interplay between KF injuries, ACL ruptures, and associated knee pathologies.

Lateral extra-articular tenodesis

Lateral extra-articular tenodesis (LET) techniques have been increasingly utilized to address residual laxity, anterior tibial translation, and internal rotation following ACLR. These techniques are crucial in managing persistent rotatory knee instability, a common complication post-ACLR.

In the clinical field, some studies have shown promising results in combining ACLR and LET. LET can be beneficial in cases of persistent rotatory knee instability following ACLR. A few long-term studies have found little difference in patient-reported outcomes and osteoarthritis development with the addition of LET to ACLR (31, 32, 33, 34). LETs have shown efficacy in reducing the incidence of ipsilateral ACL re-ruptures, postoperative pivot shift, and graft failure rates compared to ACLR, and in improving anterolateral knee stability (35). However, it has no impact on the time to return to play (6, 36, 37, 38). Subjective clinical scores (Lysholm, Tegner, and subjective International Knee Documentation Committee (IKDC)) were only marginally improved in the ACLR + LET group compared to ACLR (6, 37, 38). In revisions of ACLR, the addition of LET to the procedure has shown an improvement in subjective IKDC scores, this improvement is more significant when the laxity grade is high (grade ≥ 2). It also restored rotational stability and reduced failure rates compared to isolated revision (5, 39).

In contrast, some studies have shown that long-term adverse effects may occur in knees that have undergone the ACLR + LET procedure. For instance, the positive pivot shift and the presence of the anterior drawer test were still observed after the procedure (40). Additionally, degenerative changes and residual instability were developed in the lateral compartment (31). These degenerative changes may occur due to an increase in the constraint on the lateral part of the knee and the pressure on the lateral tibial plateau (37). Overall, some studies suggested that the combination of LET with ACLR can lead to an increased risk of knee stiffness.

In Fig. 5, we delve into the most commonly employed LET techniques, each uniquely designed to augment the stability of the knee following ACLR. Among these diverse methods, the modified superficial Lemaire (MSL) technique stands out for its remarkable similarity to the KFs in both functional and anatomical aspects (41).

Modified superficial Lemaire

Recent advancements in anterolateral knee stabilization have seen the emergence of novel techniques, notably the MSL and DKF reconstruction (KFT). These methods, evolving from the established modified deep Lemaire (MDL), show a notable similarity in functional and anatomical aspects to the intact KFs.

The KFT method, initially proposed in two technical note studies, represents a novel approach for the reconstruction of injured distal KF (42, 43). The MSL and KFT techniques utilize a 7–10 mm wide strip of the ITB. In these procedures, the attachment of this strip to the tibial part (Gerdy tubercle) is preserved. The strip is then attached proximal to the femur. The attachment of the strip on the femur in MSL and MDL is the insertion site of the ALL, which is located distal to the superior lateral genicular artery. The attachment site of the strip in KFT corresponds to the anatomical distal attachment of the KFs on the femur, which is located proximal to

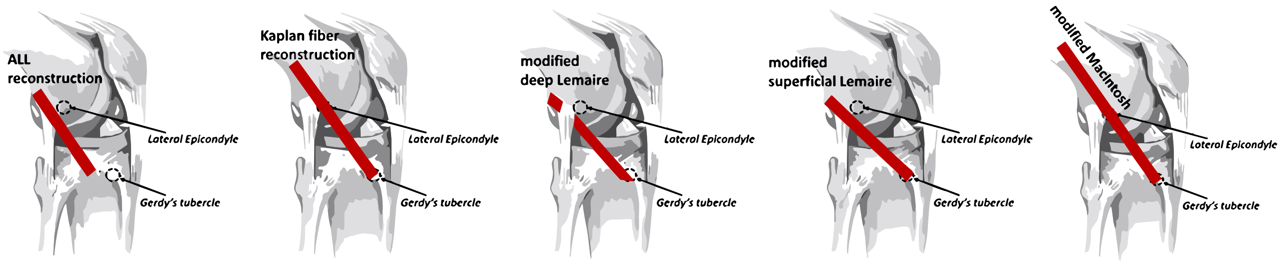

Figure 5

The anatomical scheme of some LET techniques; ALL reconstruction, Kaplan fiber reconstruction, modified deep/superficial Lemaire, and modified MacIntosh.

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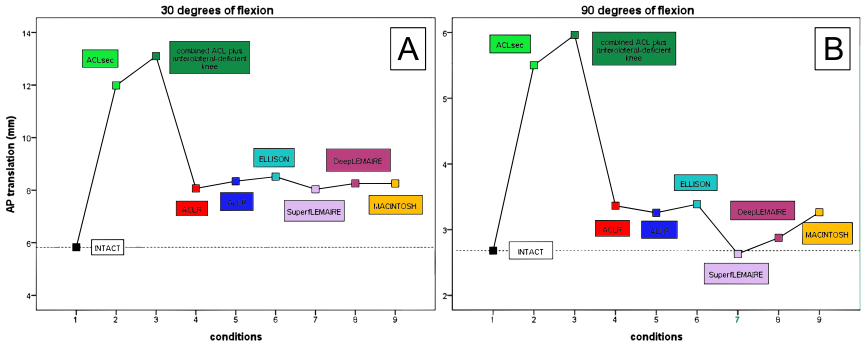

Figure 6

The internal rotation restriction in different knee flexion angles, look at the over-constriction in deep and superficial and deep Lemaire and MacIntosh procedures. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction. This figure was reproduced from Neri *et al.*'s article: 'Different Anterolateral Procedures Have Variable Impact on Knee Kinematics and Stability When Performed in Combination with Anterior Cruciate Ligament Reconstruction.' *Journal of ISAKOS*. 2021;6:74–81 under license of CC BY-NC-ND 4.0 DEED (2).

the superior lateral genicular artery. However, in MDL, the strip passes under (deep to) the LCL, making the biomechanics of the MDL technique different from KFT, MSL, and eventually the native KFs. In theory, KFT and MSL can replicate the natural course and function of the KFs (42, 43). The MSL reduces internal rotation (IR) and residual laxity more effectively compared to other LET techniques, as shown in biomechanical studies. Consequently, MSL tenodesis may be beneficial in ACLR knees that exhibit residual rotatory laxity (44).

Inderhaug *et al.*'s study was the first study that described the MSL technique and studied the biomechanics of this technique and other LET techniques such as MDL, ALL, and MacIntosh compared to intact knee. The result showed an over-constriction in both IR and anteroposterior (AP) translation in MSL especially in higher forces, torques, and higher flexion angles (45). Likewise, Ahn *et al.*, in a biomechanical comparison among single and double-bundle ACLR plus MSL, double-bundle ACLR alone, and an intact knee, showed that adding MSL to double-bundle ACLR reinstates the biomechanics of an intact knee in terms of AP translation, ER, and IR. However, in 90° of flexion, IR has been over constrained compared to an intact knee (46).

A biomechanical study by Neri *et al.* evaluated different LET techniques in combination with ACLR in the setting of deficient ACL and anterolateral structures (47). They measured IR and anteroposterior tibial translation at 30° and 90° of flexion for each technique. They found that only superficial Lemaire could restore anteroposterior tibial translation to the state of intact ACL knee (Fig. 6). In their study, isolated ACLR did not restore normal overall knee kinematics in an ACL plus anterolateral deficient knee, leaving a residual tibial rotational laxity. ALLR and modified Ellison procedure restored overall IR kinematics to the normal intact state. Superficial and deep Lemaire and modified MacIntosh techniques over constrained IR of the knee; superficial Lemaire causes more constraints compared to other techniques specifically at higher flexion angles (Fig. 7).

In another study by Neri *et al.,* they evaluated contact pressures in the lateral compartment of the knee in flexion using different LET procedures (48). They found that LET procedures did not increase the pressure during normal rotation or external rotation of the knee in different knee flexion degrees. However, they found that deep and superficial Lemaire and modified MacIntosh would increase the pressure during IR especially in flexion of more than 30°.

Despite their promising biomechanical profiles, there remains a significant gap in understanding MSL clinical effectiveness and KFT biomechanical characteristics. This necessitates focused research efforts to thoroughly assess the KFT method, comparing it to established LET procedures to determine its viability and potential advantages in clinical practice.

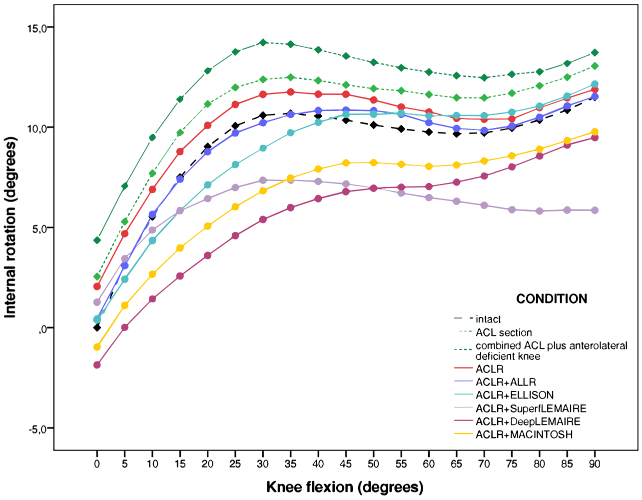

Figure 7

The anteroposterior (AP) translation comparison in 90 and 30 degree flexion, in overall the superficial Lemaire showed the best result in terms of restricting AP translation. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction; AP, anteroposterior. This figure was reproduced from Neri *et al.*'s article: 'Different Anterolateral Procedures Have Variable Impact on Knee Kinematics and Stability When Performed in Combination with Anterior Cruciate Ligament Reconstruction.' *Journal of ISAKOS*. 2021;6:74–81 under license of CC BY-NC-ND 4.0 DEED (2).

Overview, future directions, and recommendations

The comprehensive review of KFs within the ITB reveals their critical role in knee biomechanics, particularly in maintaining lateral knee stability. The review has delved into various aspects, including the anatomy, biomechanics, and clinical implications of KFs. Furthermore, the review has explored the use of MRI in diagnosing KF injuries, highlighting the variability in detection rates and the need for consistent diagnostic criteria. The role of modified Lemaire tenodesis in conjunction with ACLR has also been examined, indicating its efficacy in reducing rotational instability.

Looking ahead, future research should focus on longitudinal studies to better understand the natural healing trajectory of KF injuries and their long-term impact on knee stability and function. There is a pressing need for the development and validation of standardized MRI criteria for KF injury diagnosis to enhance inter-rater reliability and diagnostic accuracy. Further biomechanical studies are essential to comprehend the precise role of KFs in knee stability and how they interact with other knee structures during different movements and stressors. Research on KFs across various ethnic and demographic groups can provide deeper insights into anatomical variations and their clinical implications. Clinical trials should be designed to specifically assess the efficacy of various LET techniques and also rehabilitation protocols for KF injuries.

ICMJE Conflict of Interest Statement
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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