HISTORY AND INDICATIONS OF LATERAL TENODESIS IN ATHLETES

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The treatment of anterior cruciate ligament injuries remains challenging in young athletic populations. A residual laxity, even if only slight, can compromise the return to sport. Intra-articular anatomic and especially double bundle reconstructions have been advocated to improve results, but the benefits of these procedures have not been proven. Therefore, a renewed interest in lateral tenodesis and, recently, anterolateral ligament reconstruction, has been observed.

DEFINITION

Lateral tenodesis of the knee can be defined as any lateral extra-articular procedure which will control anterolateral laxity and contribute to decreased pivot shift after a rupture of the anterior cruciate ligament (ACL).

Different terms are still used for this kind of surgical procedure: lateral tenodesis, lateral extra-articular procedure, lateral extra-articular plasty, Lemaire, monoloop and anterolateral ligament (ALL) reconstruction.

The objective of these different surgical procedures is the same: controlling the internal rotation and lateral tibial plateau translation.

THE PIONEERS: ISOLATED LATERAL TENODESIS

Aside from some anecdotal accounts of surgeries performed at the beginning of the last century, Marcel Lemaire was the first to describe an isolated lateral tenodesis, in 1967[1]. It is interesting to mention that Lemaire was not actually an orthopaedic surgeon but a general surgeon at this time. He was in charge of several athletes, particularly football (soccer) players, and he noticed that some of these patients were complaining of instability of the knee and he described in French as a '*ressaut*', which means a sort of jump inside the knee that would later be termed pivot shift. At this time, intra-articular ACL reconstruction had not been developed and Lemaire wanted to address this rotational instability he had observed in the athletic population. He described his procedure as the isolated lateral tenodesis, but it came to be known as the Lemaire procedure by the French orthopaedic community.

Principles of the Lemaire procedure

The technique used an 18 cm long by 10 mm wide strip of the iliotibial band (ITB) that remained attached to Gerdy's

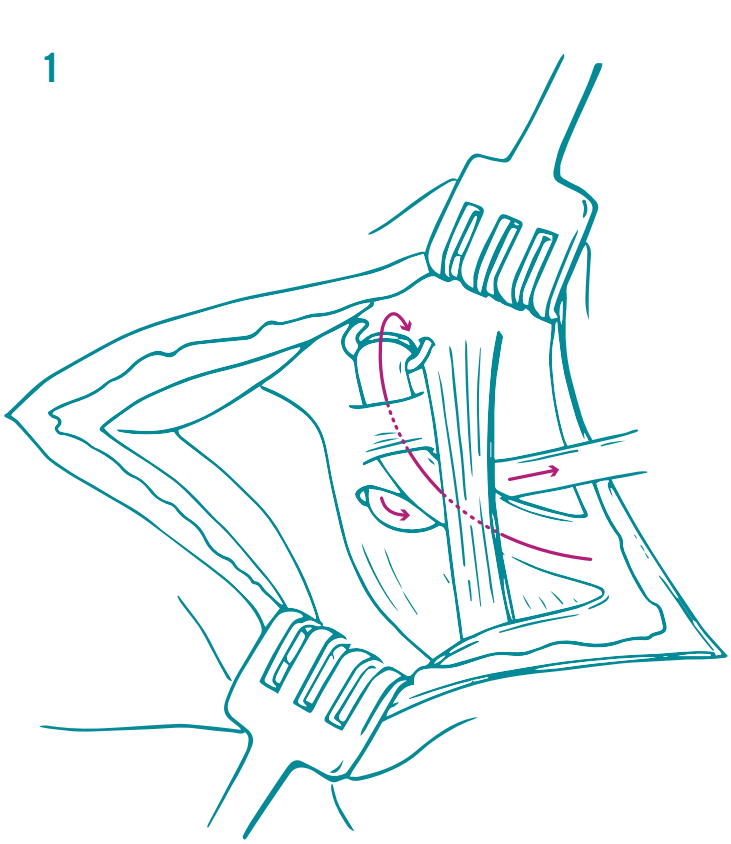

Figure 1: Lemaire procedure.

Figure 2: MacIntosh extra-articular procedure.

tubercle (Figure 1). The graft was passed deep into the fibular collateral ligament (FCL), then through a periosteal bridge and then through a femoral tunnel located proximal to the lateral femoral epicondyle. This tunnel was performed using a special curved rasp designed by Lemaire himself (a riffler). Then the graft came back under the FCL to be sutured to itself or fixed in a tibial tunnel. A Dujarier staple was added to fix and secure the graft on the femoral epicondyle to avoid any breakage of the bone or the periosteal bridge. The graft was fixed in external rotation, between 30° and 45° of flexion. After the surgery, no immobilisation was applied and the patient could walk with full weight-bearing protected by crutches for 3 weeks. Physiotherapy was only started at the end of these 3 weeks[2].

At this time, no intra-articular reconstruction of the ACL was performed. Marcel Lemaire published a series of 46 patients operated with this procedure. The results were good on return to sports activity with an excellent control of anterolateral laxity and pivot shift on a short follow-up.

Thereafter, different authors described comparable procedures. MacIntosh[3] used a distally-based strip of the ITB passed deep to the FCL, through a sub-periostal femoral tunnel, then routed back through the distal intermuscular septum, again passed deep to the FCL and, finally, anchored to the anterolateral tibia (Figure 2). In the Losee technique[4], a tunnel is made through the lateral femoral condyle, starting anterior and distal to the attachment of the FCL and exiting through the origin of the lateral gastrocnemius tendon. The graft is passed through the anteroposterior femoral tunnel, sutured to the periosteum, passed through the lateral gastrocnemius tendon, exiting through the posterolateral capsule then routed back under the FCL (Figure 3). Ellison[5] detached a bone block from Gerdy's tubercle along with the attached ITB. The graft with the bone block was then routed deep to the FCL and fixed to the tibia with a staple at 90° of knee flexion (Figure 4). Andrews[6] described a true ITB tenodesis with two small drill holes made in the distal femur allowing sutures to be passed through these holes and tied over the medial aspect of the femur (Figure 5).

The early results of these techniques were generally good, reported success ranged from 75% and 90%[7]. However, the long-term results, especially in the young athletic population, were disappointing[8]. Recurrent or residual laxity, secondary meniscus tears and degenerative changes were the main concerns after isolated extra-articular lateral tenodesis.

DEVELOPMENT OF INTRA-ARTICULAR ACL RECONSTRUCTION

During the 1980s and 90s, the progress of arthroscopy and the better understanding of the ACL anatomy allowed the development of reproducible intra-articular reconstructions with better success rates. Therefore, many surgeons abandoned the isolated extra-articular procedure in favour of the isolated intra-articular procedure. However, other surgeons continued to perform combined extra-articular and intra-articular procedures either systematically or occasionally.

The usual justifications for surgeons who combined both procedures were and still are:

1. Protection of the ACL graft. Engebretsen et al, in a 1990 cadaveric study, showed that lateral extra-articular tenodesis reduced the forces going through an intra-articular reconstruction by 43%[9].

2. The treatment of concomitant injuries to anterolateral structures. During an ACL rupture there is frequently significant internal rotation of the tibia with a true subluxation or luxation of the tibial plateau. Bone bruise observed on MRI on the posterior tibial plateau and the lateral condyle is the best illustration of displacement during the ACL rupture. This displacement probably doesn't exist without damage to the anterolateral structures. Segond described an avulsion of the distal capsule, but it is probable that the other anatomic structures can also be damaged[10].
3. The counterbalance of an imperfect intra-articular ACL reconstruction. Despite the improvement in surgical techniques for intra-articular reconstruction, it is clear that it does not always provide perfect control of anterolateral instability. This can warrant combined anterolateral reconstruction to reinforce the imperfections of intra-articular reconstruction.

Figure 3: Losee procedure.

Figure 4: Ellison procedure.

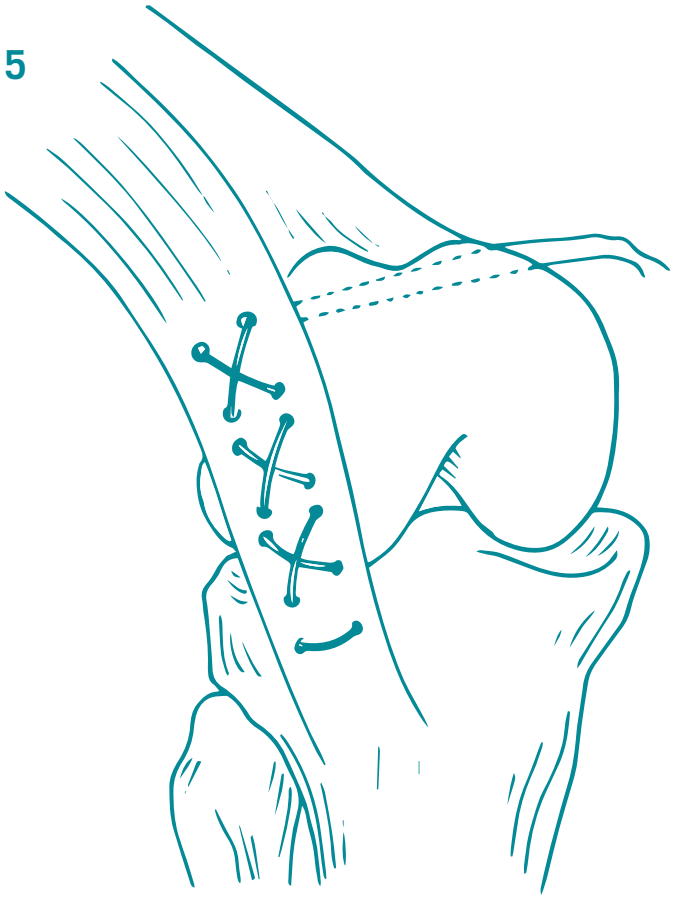

Figure 5: Andrews procedure.

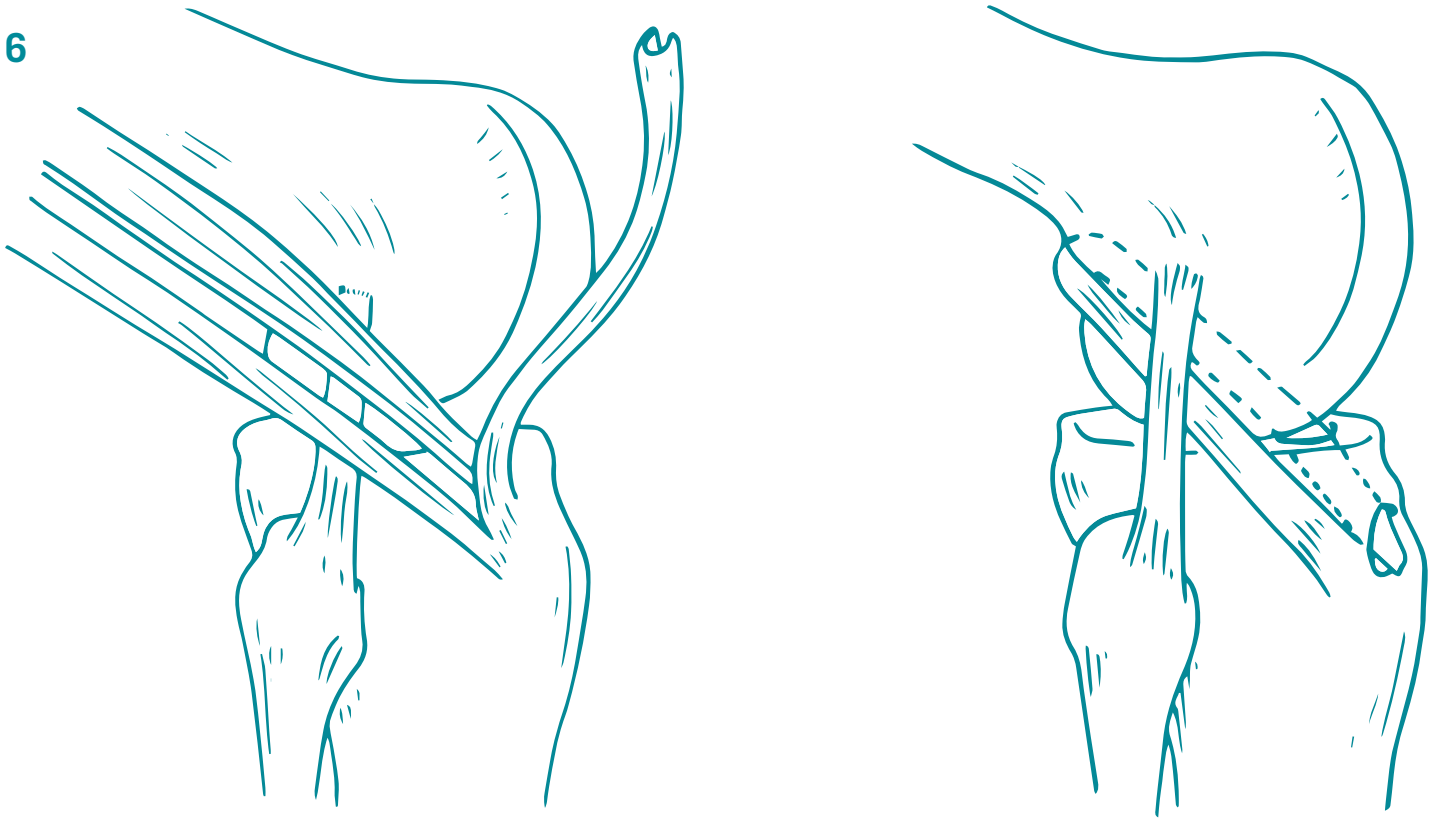

Figure 6: MacIntosh extra- and intra-articular procedure.

Numerous combined intra- and extra-articular reconstruction techniques have been developed, the most popular being the MacIntoch technique[11]. In 1977, he modified his original extra-articular procedure by routing the ITB over the top of the lateral femoral condyle (Figure 6). The graft was then brought through the knee joint and into a tibial tunnel to restore the ACL. Marshall popularised this technique by using a quadriceps-patellar tendon graft. This technique was quite popular and some modifications were developed, such as the 'MacInJones'[12]. Marcacci et al described a technique using the gracilis and semi-tendinous tendon to perform the MacIntosh. The tendons remain attached to the tibia, are passed through an ACL tibial tunnel and then brought 'over the top' onto the lateral femoral condyle, where the intra-articular portion of the graft is fixed with staples. The tendons are then passed underneath the ITB and fixed at Gerdy's tubercle with two staples. That team is still using the same procedure[13]. Nowadays the majority of the surgeons combine an independent intra-articular graft and a modified Lemaire technique[14]. The intra-articular reconstruction is performed using either bone-tendon-bone, hamstrings or quadriceps graft and the lateral tenodesis (modified Lemaire technique) is added case by case.

The results of this combined procedure are still controversial as varying techniques are used, making comparison difficult. The addition of a lateral tenodesis reduces pivot shift more than an isolated intra-articular reconstruction, although there is no obvious difference in term of patient-reported outcome scores[15].

Unlike isolated lateral tenodesis, the addition of a lateral tenodesis to an intra-articular procedure have not shown an increased risk of osteoarthritis[16].

Patient selection

The usual indications for combined intra- and extra-articular procedures are currently high-grade rotation laxity (pivot shift grade 3), high-demand and contact athletes, generalised ligamentous laxity and ACL revision. There is still no evidence about exact and accurate indications for lateral tenodesis.

THE ANTEROLATERAL LIGAMENT YEARS

Since 2000, several teams have developed the concept of anatomic ACL reconstruction including the double bundle graft in order to restore the original anatomy of the ACL and to control internal rotation of the tibia. Despite this clear improvement of the technique and of the anatomical reconstruction of the ACL, many patients were still unable to return to sports and up to 25% of patients had a persistent pivot shift. Concomitant injuries to lateral capsuloligamentous structures may explain some failures of intra-articular ACL reconstructions. As a result, there has been a renewed interest in the anatomy of the lateral part of the knee and extra-articular procedures. The anterolateral ligament of the knee was initially described by Vincent et al in 2012[17] and then by Claes[18] in the *Journal of Anatomy*, in 2013, which accurately described the anatomy of this 'new' ligament. Despite several anatomical and biomechanical studies, the exact anatomy and role of the anterolateral ligament are still debated. Nevertheless some surgeons have already developed specific anterolateral reconstruction techniques with good clinical results[19].

THE PRESENT AND THE FUTURE

Nowadays there is clearly an enthusiasm for the anterolateral ligament and its

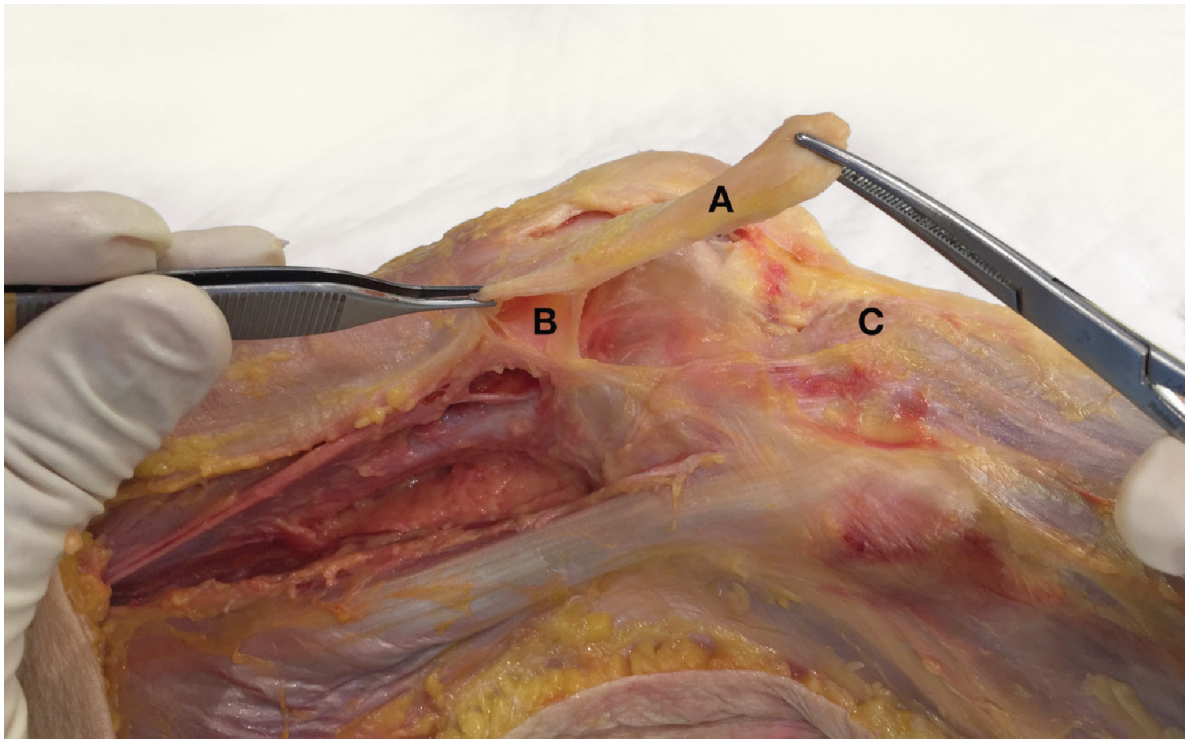

Figure 7: Identification of an anatomic ligamentous structure controlling anterolateral stability of the knee. A=iliotibial band. B=anatomic structure providing a tenodesis effect, beside the Kaplan fibers. C=Gerdy's tubercule.

reconstruction, however there are still unsolved questions:

- Is the ALL the only or the main lateral control of tibia translation?
- Is the ALL the only structure to be repaired or restored?

Some recent anatomical studies have shown that the role of the ALL is probably overestimated in comparison to the iliotibial band tract, which could be the primary restraint of tibial plateau displacement[20]. At the same time, other anatomical studies have shown that lateral extra-articular tenodesis using a modified Lemaire technique to be superior at controlling anterolateral rotational laxity and anterior translation compared with ALL reconstruction[21]. Kaplan, in 1958[22], noted that there are strong connections between the deep surface of the iliotibial band and the lateral epicondyle. Terry and Hughston in 1986[23], and Viera et al in 2007[24] confirmed the complexity of the anterolateral structure, which could certainly not be summarised only by the anterolateral ligament.

A recent anatomical study by Landreau et al[25] on the anterolateral structure described an anatomic ligamentous structure located in the deep layer of the iliotibial band, in the area of the Kaplan fibres. This structure had a clear iliotibial band tenodesis effect and could be clearly distinguished from the anterolateral ligament (Figure 7).

CONCLUSION

The use of lateral tenodesis procedures started 50 years ago and a variety of reconstructions have been described over the past 5 decades. Even though an isolated extra-articular procedure should not be recommended as it can lead to early osteoarthritis, the combination of an intra- and extra-articular procedures can decrease the rotatory laxity.

ALL reconstructions have been described recently but constitute the same concept as a lateral tenodesis. We still don't know accurately which patients would benefit from a lateral tenodesis procedure and the ideal technique is still unidentified. Further anatomic studies[26], considering all the lateral structures, especially the ITB and not only the ALL, will likely guide us to define the optimal lateral tenodesis to be performed for a patient with a high risk of residual rotational knee laxity.

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