Editorial Commentary: Nonanatomic Lateral Extra-Articular Procedures Performed at the Time of Anterior Cruciate Ligament Reconstruction Risk Overconstraint: Anatomic Anterolateral Ligament Reconstruction Does Not

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Abstract: Isolated anterior cruciate ligament reconstruction is associated with a risk of graft rupture that is more than 5-fold higher than that of combined anterior cruciate ligament—anterolateral ligament (ALL) reconstruction at a mean follow-up of greater than 100 months. However, biomechanical and clinical studies report that overconstraint is a concern with nonanatomic lateral-sided reconstruction. In fact, the normal biomechanics of the native ALL are anisometric. The ligament is tight in extension (providing rotational control) and slack in flexion (allowing physiological internal rotation). The ALL femoral attachment is proximal and posterior to the lateral epicondyle. The tibial tunnel or tunnels are located anterior to the fibular head and posterior to the Gerdy tubercle. An ALL graft must lie deep to the iliotibial band and superficial to the lateral collateral ligament. Fixation is performed in extension and neutral rotation. A single- or double-strand technique may be used. Surgeons performing lateral extra-articular procedures must understand the technical pitfalls that can lead to overconstraint and must seek to avoid them. Overconstraint can occur for a number of reasons, including the use of nonanatomic reconstruction and technical errors in tensioning, fixation angle, and tunnel positioning.

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Lateral extra-articular procedures performed at the time of anterior cruciate ligament (ACL) reconstruction are increasingly popular. A plethora of new techniques with variable fixation angles and tunnel positions have been described, and there is ongoing debate regarding which technique is optimal. I congratulate Xu, Ye, Han, Xu, Zhao, and Dong[1] for their elegant study entitled "Anterolateral Structure Reconstructions With Different Tibial Attachment Sites Similarly Improve Tibiofemoral Kinematics and Result in Different Graft Force in Treating Knee Anterolateral Instability." They report that anterior, middle, and posterior tibial attachment sites all similarly restored knee laxity close to the native state but also that all reconstructions were associated with some degree of overconstraint. These findings are of great value in highlighting some important potential pitfalls in lateral extra-articular reconstruction.

In my opinion, the most important message from the study by Xu et al.[1] is that nonanatomic lateral extra-articular procedures risk overconstraint. Indeed, it is not clear from the current article exactly what structure the authors intended to reconstruct, but in a recent letter to the editor regarding a different study from the same institution,[2] the authors reported that their augmentation procedure "was based on the concept of the rotatory functional restoration, neglecting the precise anatomy of the ALL [anterolateral ligament] or ALC [anterolateral complex]."[3] The authors' justification for this procedure was their belief that "the clinical effect of the lateral extra-articular procedure is not ascertained."[3] I disagree with this statement on the basis that there are numerous comparative studies reporting significant benefits of combined ACL-ALL reconstruction[4] (including studies of young patients

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participating in pivoting or contact sports,[5] professional athletes,[6] patients undergoing revision ACL reconstruction,[7] patients with chronic injuries,[8] patients with hyperlaxity,[9] and patients undergoing medial meniscal repair[10,11]). The SANTI (Scientific ACL Network International) Study Group has also recently shown that isolated ACL reconstruction is associated with a risk of graft rupture that is more than 5-fold higher than that of combined ACL-ALL reconstruction at a mean follow-up of greater than 100 months.[12] These consistent findings across a wealth of studies, including at long-term follow-up, provide confidence in the clinical effectiveness of combined ACL-ALL reconstruction. It is also noteworthy that among specific investigations of complications and reoperations, no cases of overconstraint were identified.[13,14] These studies share several key characteristics that seem to be important in minimizing the risk of overconstraint:

1 They aim to reconstruct a specific anatomic structure (the ALL) with precise landmarks and known biomechanics.
2 A femoral attachment proximal and posterior to the lateral epicondyle is used.
3 The reconstruction lies deep to the iliotibial band and superficial to the lateral collateral ligament.
4 Fixation is performed in extension and neutral rotation.
5 A single- or double-strand technique is used, with the tibial tunnel or tunnels located anterior to the fibular head and posterior to the Gerdy tubercle.

Although Xu et al.[1] report that (based on the ALL anatomy) they have used a femoral position that is proximal and posterior to the lateral epicondyle, the laboratory photographs and illustrations show a location that is at the level of (not proximal to) and posterior to the lateral epicondyle (Fig 1). This point may seem pedantic, but it is important point because it likely explains a large proportion of the overconstraint observed in the current study. Of clinical relevance, this is also a pitfall to be aware of and avoid intraoperatively.

There is a clear consensus that the normal biomechanics of the native ALL are anisometric and that its femoral attachment is proximal and posterior to the lateral epicondyle.[15] The ligament is tight in extension (providing rotational control) and slack in flexion (allowing physiological internal rotation).[16,17] For a reconstruction to replicate this anisometry, an anatomic femoral position that is proximal and posterior to the lateral epicondyle is required (Fig 2). In a previous surgical technique note, we provided a video specifically highlighting the consequences of tunnel malposition during ALL reconstruction.[18] We showed that selecting a femoral attachment site at the level of the lateral epicondyle restricts internal rotation during knee

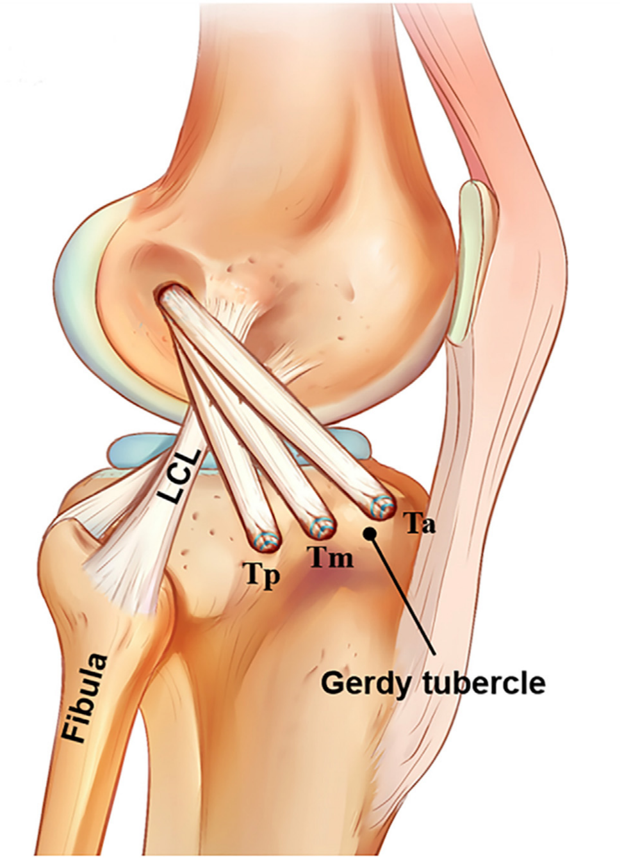

Fig 1. Illustration of lateral extra-articular reconstruction evaluated by Xu et al.,[1] revealing a femoral tunnel at the level of (not proximal to) and posterior to the lateral epicondyle. Reprinted with permission from Elsevier. (LCL, lateral collateral ligament; Ta, anterior tibial attachment; Tm, middle tibial attachment; Tp, posterior tibial attachment.)

flexion and therefore causes overconstraint.[18] These observations are consistent with those of Xu et al.,[1] who also showed that overconstraint (less tibial anterolateral translation than the native state on simulated pivot shift) occurred with their chosen femoral position, regardless of which tibial tunnel position was used. Furthermore, the authors reported that these findings were most pronounced at 45° of flexion,[1] which is in contrast to the normal biomechanics of the ALL because we would typically expect slackening with deeper knee flexion angles.[17]

With respect to tibial tunnel position, Xu et al.[1] showed that all positions were able to control the rotatory instability that resulted from sectioning of the anterolateral structures but found that each location provided a different degree of control and resulted in different degrees of loading during the pivot shift. These results are consistent with those of our previous studies, which showed that altering the tibial tunnel position can significantly alter control of knee rotation and translation but that the magnitude of the effect is

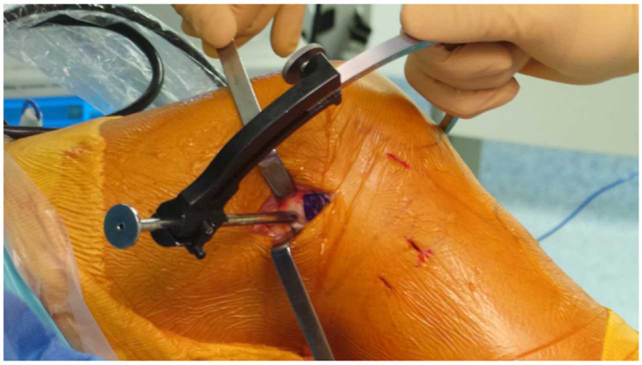

Fig 2. Intraoperative photograph of lateral aspect of right knee. A surgical marking pen has been used to highlight the lateral collateral ligament and the lateral epicondyle. The femoral guide is positioned so that an outside-in wire enters the lateral cortex at the anatomic footprint of the anterolateral ligament, which is proximal and posterior to the lateral epicondyle. (Reproduced with permission from Saithna A, Thaunat M, Delaloye JR, Ouanezar H, Fayard JM, Sonnery-Cottet B. Combined ACL and anterolateral ligament reconstruction. *JBJS Essent Surg Tech* 2018;8:e2.)

dependent on the femoral tunnel position and knee flexion angle at fixation.[17,19] Regardless, a notable finding from Xu et al. was that the tibial attachment position anterior to Gerdy's tubercle was associated with the most overconstraint. This is a location that is inconsistent with the attachment sites for both ALL reconstruction and iliotibial band–based procedures such as the modified Lemaire procedure, and again, this should serve to highlight the point that nonanatomic reconstruction risks overconstraint.

Historically, there has been considerable concern about overconstraint, and it is one of the reasons why extra-articular procedures were widely abandoned in the 1980s. At that time, there was a tendency to perform fixation in flexion and external rotation and to immobilize knees postoperatively in full extension for prolonged periods, both of which could lead to knee stiffness. However, a systematic review of long-term studies has suggested that concerns about overconstraint may be unwarranted because it did not show an increased rate of osteoarthritis with lateral extra-articular procedures.[20] Regardless, it is not confirmed that these issues have been fully resolved in contemporary practice. Although it is clear that combined reconstruction with either an ALL reconstruction or modified Lemaire procedure can restore normal knee kinematics without overconstraining the knee,[21] it is my opinion that overconstraint is perhaps more likely with a modified Lemaire procedure (because it is nonanatomic and the knee is fixed in flexion) when compared with an ALL reconstruction (anatomic, with the knee fixed in extension, replicating the normal biomechanics and anisometry of the ALL); this is supported by several biomechanical studies[17,22-26] and a clinical report of overconstraint from the STAbiLiTY (Standard ACL Reconstruction vs ACL + Lateral Extra-Articular Tenodesis) study.[27] However, the issue is clouded by the fact that we do not have a clear consensus on the definition of "overconstraint" and what degree of overconstraint is clinically important. Although it is reassuring that long-term studies have not shown an increased risk of osteoarthritis, this remains an area that requires further study.

A further important point to highlight is that Xu et al.[1] report an original technique and coin the term "anterolateral structure reconstruction" to describe it. This is reflective of the recent publication of an abundance of newly described lateral extra-articular techniques. In my opinion, given the wealth of clinical data supporting existing techniques (including long-term data), there is little justification for using a technique that is not supported by robust clinical data. Furthermore, I recommend against the use of new nomenclature because it is well recognized that the orthopaedic community's quest for consensus on this topic has been hampered by confusing and overlapping terminology. In fact, numerous terms, including "capsulo-osseous layer," "short lateral ligament," "anterior oblique band," "anterior band of the lateral collateral ligament," and "middle-third lateral capsular ligament," have all been used variably and sometimes interchangeably. Furthermore, using established and agreed-upon nomenclature[15] helps to make clear exactly what anatomic structure is being reconstructed and, therefore, what its precise landmarks, expected biomechanics, and expected clinical outcomes are.

In summary, I again congratulate Xu et al.[1] on their insightful study, which has helped to highlight that the issue of overconstraint remains an important consideration in lateral extra-articular reconstruction. Overconstraint can occur for a number of reasons, including the use of nonanatomic reconstruction and technical errors in tensioning, fixation angle, and tunnel positioning. Furthermore, the biomechanics of soft-tissue grafts versus synthetic grafts (such as those used by Xu et al.) have not been fully elucidated, and it is not clear whether the latter are associated with a greater risk of overconstraint. I recommend that surgeons performing lateral extra-articular procedures understand the technical pitfalls that can lead to overconstraint and seek to avoid them.

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