



Modified Lemaire Lateral Extra-articular Tenodesis in the Pediatric Patient: An Adjunct to Anterior Cruciate Ligament Reconstruction

Lindsay M. Schlichte, M.S., Alexandra H. Aitchison, B.S., Daniel W. Green, M.D., M.S., and Frank A. Cordasco, M.D., M.S.

Abstract: Recent literature has identified a population of active adolescents aged 13 to 15 years who are at high risk for anterior cruciate ligament graft rupture. Addressing the anterolateral complex during primary anterior cruciate ligament reconstruction has recently re-emerged in the literature, with various techniques available. This paper aims to describe a lateral extra-articular tenodesis procedure using the iliotibial band with a modified Lemaire technique. This procedure is recommended for active adolescents at a high risk of graft re-tear as an enhancement to primary anterior cruciate ligament reconstruction with soft-tissue graft.

Anterior cruciate ligament (ACL) tears are a common injury in the pediatric population and are being recognized and treated with increasing frequency.^{1,2} In a meta-analysis, Wiggins et al.³ noted that nearly 1 in 4 young athletic patients who sustain an ACL injury and return to high-risk sports will go on to sustain another ACL injury at some point in their career. Surgical techniques to address ACL tears in growing children and adolescents have rapidly evolved to minimize the risk of growth disturbance and re-tear.⁴

Addressing the anterolateral complex (ALC) during anterior cruciate ligament reconstruction (ACLR) has recently re-emerged in the literature. The ALC

includes several structures: the iliotibial band (ITB), distal and proximal Kaplan's fibers, the anterolateral ligament (ALL), and the capsular attachment of the lateral meniscus. Noyes et al.⁵ described the role of the ALL and ITB in knee rotational stability with cadaveric knee specimens. Their results showed that the ITB acts as a secondary restraint to tibial translation and internal rotation and that the ALL and ITB functioned in some knees as the primary restraint for internal rotation at high flexion angles.⁵ These results suggest that an insufficient or injured ALC puts a significant force on an ACL, especially in sports involving cutting, jumping, and pivoting.

Research regarding ITB tenodesis as a supplemental procedure to ACLR is limited and primarily involves skeletally mature patients.^{6,7} In an attempt to address the previously reported population of active adolescents at a high risk of graft re-tear, this paper aims to describe a lateral extra-articular tenodesis (LET) procedure using the ITB with a modified Lemaire technique to use as an enhancement to ACLR with soft-tissue graft in the high-risk athlete within the pediatric population.^{8,9}

Surgical Technique: Modified Lemaire ITB Tenodesis (With Video Illustration)

To begin, with the patient positioned supine and the knee in 90° of flexion, a lateral incision is performed beginning at the level of the femoral insertion of the lateral collateral ligament (LCL) and extended

From the Hospital for Special Surgery, New York, New York, U.S.A.

The authors report the following potential conflict of interest or source of funding: D.W.G. reports personal fees from Arthrex, personal fees from Pega Medical, outside the submitted work. F.A.C. reports other from Arthrex, outside the submitted work; In addition, F.A.C. has a patent (Arthrex) with royalties paid, a patent (Wolters/Kluwer) with royalties paid, and a patent (Mosby/Sanders) with royalties paid and also reports Journal of Shoulder and Elbow Surgery board of trustees and American Shoulder and Elbow Surgeons executive board. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received June 26, 2019; accepted September 11, 2019.

Address correspondence to Frank A. Cordasco, M.D., M.S., Hospital for Special Surgery, 535 East 70th St., New York, NY 10021. E-mail: cordascof@hss.edu

© 2019 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/19817

<https://doi.org/10.1016/j.eats.2019.09.010>

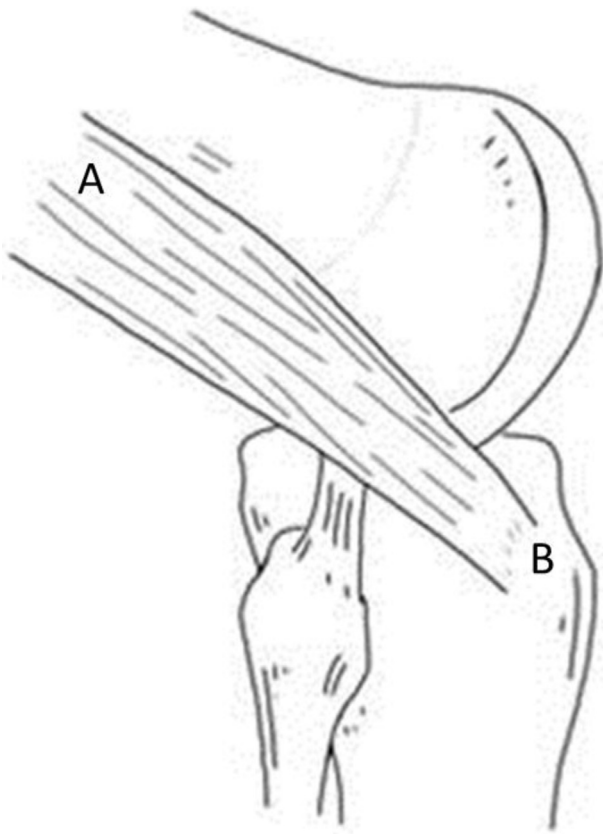


Fig 1. Schematic of a lateral view of the right knee. The ITB (A) is exposed and left attached distally at Gerdy's Tubercle (B). (ITB, iliotibial band.)

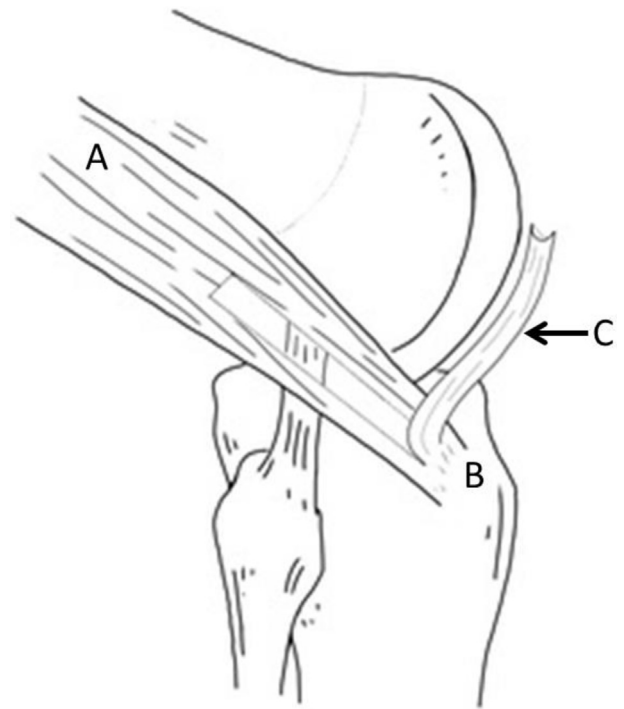


Fig 2. Schematic of a lateral view of the right knee. The ITB (A) is harvested proximally leaving the distal end attached to Gerdy's Tubercle (B) and producing an 8-cm \times 1-cm graft from the central third of the ITB (C). (ITB, iliotibial band.)

proximally for 5 cm. Dissection is taken through subcutaneous tissues to the ITB (Fig 1). A central 8-cm \times 1-cm strip of ITB is harvested and left attached distally to Gerdy's tubercle (Fig 2). Care is taken to avoid the important Kaplan's fibers posteriorly. The ITB graft is then whipped stitched (Fig 3). After the LCL is identified, the graft is passed deep (medial) to the LCL. Intraoperative fluoroscopy (mini c-arm) is recommended to confirm positioning of a drill guide directed distal to the distal femoral physis with an anterior trajectory (to avoid convergence with the femoral socket of the ACLR) and just proximal and posterior to the femoral insertion of the LCL (Fig 4). In 30° of flexion and neutral rotation, the ITB graft is secured with an all-suture anchor (Fig 5). We currently prefer fixation with an all-suture anchor (1.3-mm DX FiberTak Suture Anchor; Arthrex, Naples, FL); however, PEEK (polyether ether ketone) or biocomposite suture anchors also may be used at the surgeon's discretion. The ITB graft is then passed lateral to the LCL and secured to itself using a nonabsorbable #2 suture to complete the tenodesis (Fig 6). The ITB donor defect is then closed using #2 nonabsorbable sutures in an interrupted simple fashion to complete the LET (Fig 7).

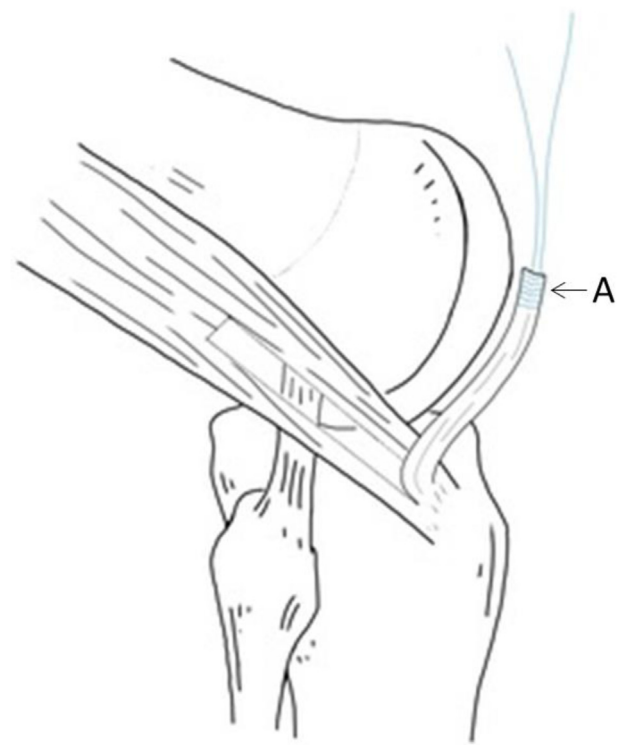


Fig 3. Schematic of a lateral view of the right knee. The proximal end of the ITB graft is whipped stitched (A). (ITB, iliotibial band.)



Fig 4. Anteroposterior intraoperative fluoroscopy with the knee in 30° flexion confirming the positioning of a drill guide (A) directed distal to the distal femoral physis (B) starting just proximal and posterior to the femoral insertion of the LCL. (LCL, lateral collateral ligament.)

A video detailing the technique is shown in [Video 1](#). Pearls and pitfalls and advantages and disadvantages of this adjunct technique are described in [Tables 1](#) and [2](#), respectively.

Discussion

Previous research on anterolateral stabilization in adults has been reported with favorable outcomes. Sonnery-Cottet et al.¹⁰ compared the graft rupture rate in 3 ACLR groups: 4-strand hamstring tendon (HT), bone–patellar tendon–bone (BPTB), and HT + ALL. The combined HT and ALL graft group experienced 2.5 and 3.1 times less graft rupture compared with BPTB and 4HT, respectively at minimum 2-year follow-up.¹⁰ Marcacci et al.¹¹ reported a 10- to 13-year follow-up on 54 patients who underwent ACLR with a similar technique. After 11 years, only 2 patients had >5 mm manual maximum side-to-side difference in laxity based on the KT-2000 arthrometer. The mean Lysholm score was 97.3, and the mean subjective score was 90.0%. Radiographic evaluation demonstrated progressive joint narrowing for 20 patients who had had concomitant medial meniscal surgery. In addition, there are 2 systematic reviews addressing the clinical outcomes of combined lateral extra-articular tenodesis and intra-articular ACLR.^{12,13} Results from both studies demonstrate the effectiveness of LET procedures in the elimination of high-grade pivot-shifts.

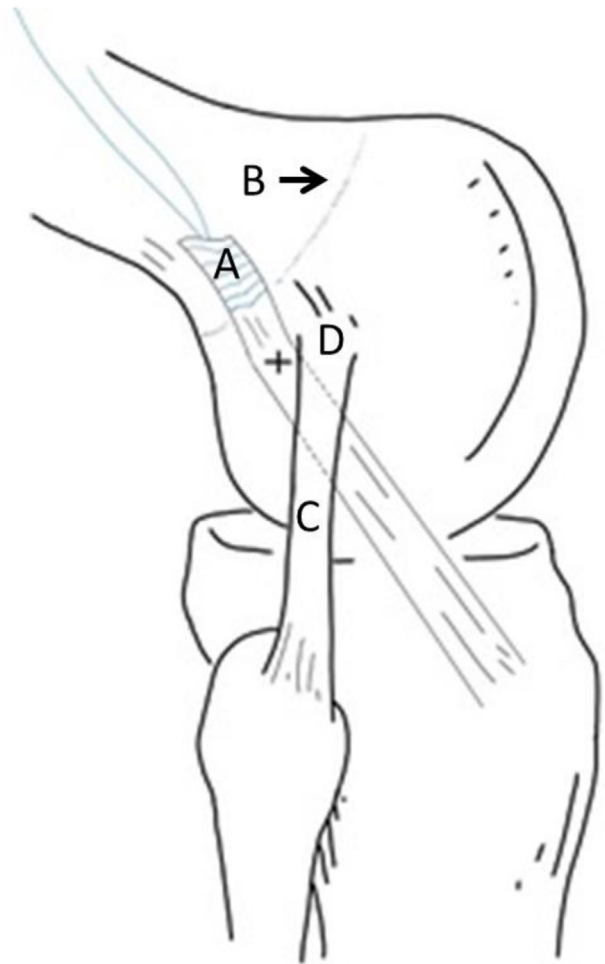


Fig 5. Schematic of a lateral view of the right knee. Shown is the ITB graft (A) passing deep to the lateral collateral ligament (C) and anchored (represented by the X) distal to the distal femoral growth plate (B) and just proximal and posterior to the LCL femoral insertion (D). (ITB, iliotibial band; LCL, lateral collateral ligament.)

Most recently, a 2018 study prospectively compared 82 patients undergoing ACLR (BPTB autograft) with either an ITB LET or gracilis LET procedure.¹⁴ The results at a mean of 13 months follow-up showed that the ACLR with ITB LET group had no extra risk of preoperative complication or reconstruction failure compared with the gracilis LET procedure group. Revision surgery was significantly more frequent in the gracilis LET group (31.7%) compared with the ITB LET group (7.3%). As growing literature supports anterolateral stabilization and its role in preventing graft rupture in adults, this article describes a technique that can be used in young athletes undergoing ACLR who are at high risk for graft rupture.

Recently, Cordasco et al.¹⁵ reported the 2-year return to sport and reoperation rates in 324 athletes younger than 20 years of age who underwent ACLR. Surgical technique was based on skeletal age and included an all-epiphyseal technique with hamstring autograft,

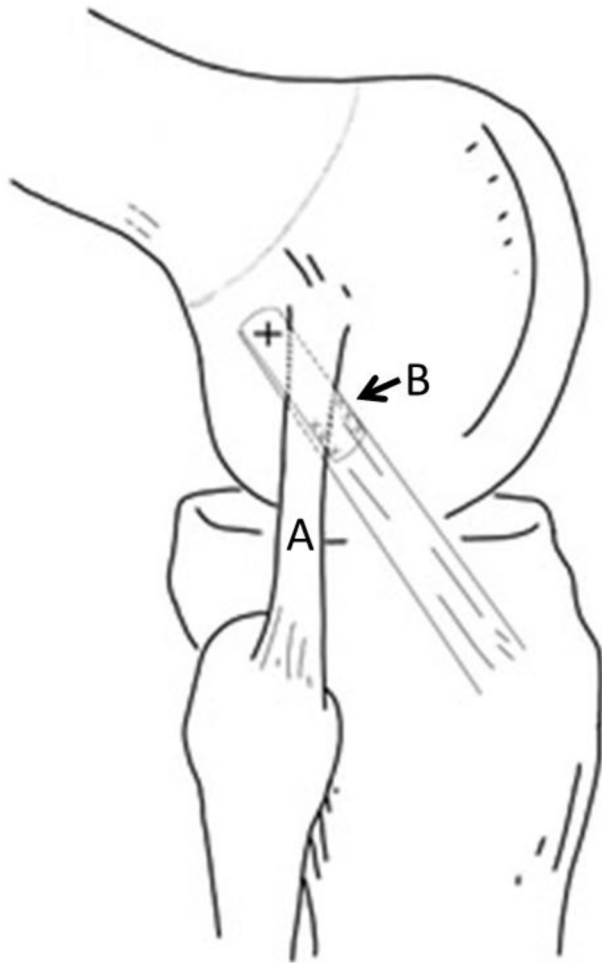


Fig 6. Schematic of a lateral view of the right knee. After the ITB graft is anchored (represented by the X), the proximal remnant of the graft is brought lateral to the LCL (A) and sutured onto itself (B) with #2 sutures. (ITB, iliotibial band; LCL, lateral collateral ligament.)

partial transphyseal and complete transphyseal with hamstring autograft, and BPTB autograft. The rate of revision ACLR was significantly greater (20%) in the partial transphyseal/complete transphyseal with hamstring autograft group compared with the all-epiphyseal technique with HT autograft and BPTB groups (both 6%).¹⁵ These results highlight a group of 8th- and 9th-grade adolescents who are at high risk for graft rupture. There are several potential explanations for this greater rate of revision, including surgical technique, graft choice, level of competition, and the physical and sports-specific development of the athlete. There are also, however, nonmodifiable physical risk factors that should be considered during surgical planning.

The indications for this modified Lemaire ITB tenodesis procedure have not been definitively established. We currently recommend considering this procedure to enhance the ACLR for patients in 8th and 9th grade

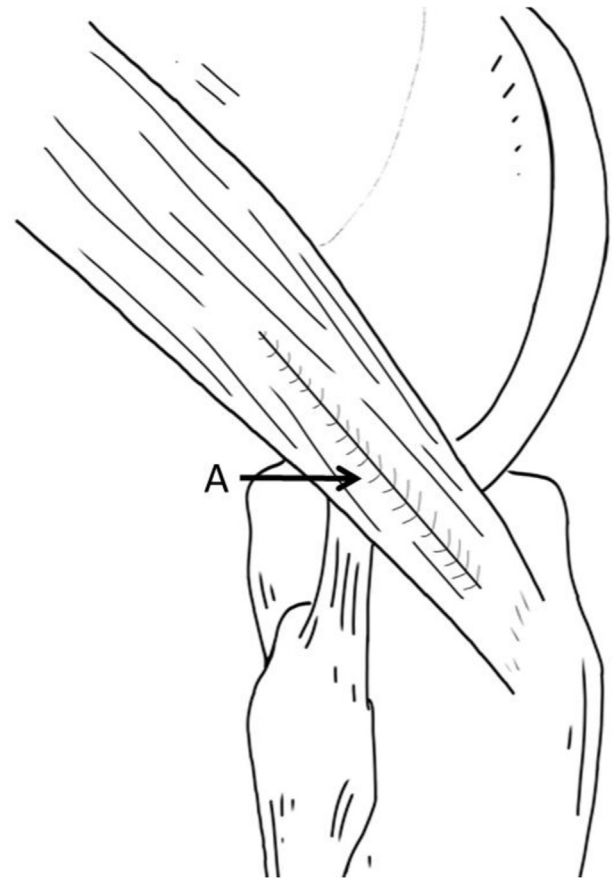


Fig 7. Schematic of a lateral view of the right knee. The ITB donor site (A) is then closed over the tenodesed ITB graft with #2 sutures in an interrupted simple fashion. (ITB, iliotibial band.)

(ages 13-15 years) who participate in high-risk competitive sports requiring cutting, pivoting, and jumping. High-risk sports in our practice include football, lacrosse, soccer, and basketball. These patients are also indicated if they present with a grade 3 pivot shift, anterior translation >7 mm side-to-side difference, lateral tibial slope $>7^\circ$, recurvatum $>10^\circ$, notch width index <0.22 , large marrow edema patterns involving

Table 1. Pearls and Pitfalls of a Modified Lemaire ITB Tenodesis

Harvest Incision can be Limited to 5 cm or less
Avoid Kaplan's fibers posteriorly when harvesting the ITB graft
Direct the tenodesis anchor drill distal to avoid the growth plate and anterior to avoid convergence with the distal femoral socket of ACLR
Consider the use of intraoperative fluoroscopy to ensure graft fixation does not compromise the femoral physis
Minimize the potential for overconstraint by maintaining the tibia in neutral rotation at the time of fixation and tensioning
Avoid over-tensioning of the graft, as the goal of the procedure is to serve as a checkrein

ACLR, anterior cruciate ligament reconstruction; ITB, iliotibial band.

Table 2. Advantages and Disadvantages of a Modified Lemaire Iliotibial Band Tenodesis

Advantages	Disadvantages
Diminishes recurrence rate and increases the return to sport rate in a high-risk population of athletes with nonmodifiable risk factors	Additional surgical approach and scar
	Additional time in the operating room
	The potential for overconstraint

the lateral tibial plateau and lateral femoral condyle or hyperlaxity (Beighton >6).⁹ Other important considerations are patients with chronic ACL insufficiency, contralateral ACLR, or revision ACLR.

The 2 most significant risks and limitations of this procedure include the potential for compromise of the distal femoral physis and convergence of the tenodesis suture anchor with the femoral socket of the ACLR. Long-term considerations include potential overconstraint and the subsequent development of degenerative arthritis. Although there are limited data, Devitt et al.¹⁶ reported in a best-evidence study that no increased rate of osteoarthritis developed 11 years after isolated LET and primary ACLR augmented with a LET procedure.¹⁶

Our experience with this technique has shown promising results thus far. To date, 51 patients younger than 20 years of age have undergone the modified Lemaire



Fig 8. Postoperative coronal magnetic resonance imaging of a 12-year-old girl 7.5 months following transphyseal anterior cruciate ligament reconstruction with quad autograft and lateral extra-articular tenodesis in the form of an iliotibial band tenodesis. Note how the lateral anchor (A) is just distal to the femoral physis (B).

procedure alongside ACLR with quadriceps tendon autograft. None of the patients have experienced graft tear or other significant complications. Thirty-one patients have postoperative magnetic resonance imaging, which demonstrates an intact graft (Fig 8). With favorable short term preliminary results, we recommend this procedure as an enhancement to primary ACLR for active adolescents at a high risk of graft retear.

References

1. Tepolt FA, Feldman L, Kocher MS. Trends in pediatric ACL reconstruction from the PHIS database. *J Pediatr Orthop* 2018;38:e490-e494.
2. Dodwell ER, LaMont LE, Green DW, Pan TJ, Marx RG, Lyman S. 20 years of pediatric anterior cruciate ligament reconstruction in New York State. *Am J Sports Med* 2014;42:675-680.
3. Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: A systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861-1876.
4. Popkin CA, Wright ML, Pennock AT, et al. Trends in management and complications of anterior cruciate ligament injuries in pediatric patients. *J Pediatr Orthop* 2018;38:e61-e65.
5. Noyes FR, Huser LE, Levy MS. Rotational knee instability in ACL-deficient knees: Role of the anterolateral ligament and iliotibial band as defined by tibiofemoral compartment translations and rotations. *J Bone Joint Surg Am* 2017;99:305-314.
6. Aglietti P, Buzzi R, D'andria S, Zaccherotti G. Long-term study of anterior cruciate ligament reconstruction for chronic instability using the central one-third patellar tendon and a lateral extraarticular tenodesis. *Am J Sports Med* 1992;20:38-45.
7. O'Brien SJ, Warren RF, Wickiewicz TL, et al. The iliotibial band lateral sling procedure and its effect on the results of anterior cruciate ligament reconstruction. *Am J Sports Med* 1991;19:21-24.
8. Lemaire M. Chronic knee instability. Technics and results of ligament plasty in sports injuries. *J Chir (Paris)* 1975;110:281-294.
9. Price MJ, Tuca M, Cordasco FA, Green DW. Non-modifiable risk factors for anterior cruciate ligament injury. *Curr Opin Pediatr* 2017;29:55-64.
10. Sonnery-Cottet B, Saithna A, Cavalier M, et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 years: A prospective comparative study of 502 patients from the SANTI study group. *Am J Sports Med* 2017;45:1547-1557.
11. Marcacci M, Zaffagnini S, Giordano G, Iacono F, Presti M, Lo. Anterior cruciate ligament reconstruction associated with extra-articular tenodesis: A prospective clinical and radiographic evaluation with 10-to 13-year follow-up. *Am J Sports Med* 2009;37:707-714.
12. Song G, 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;32:898-905.
13. Hewison CE, Tran MN, Kaniki N, Remtulla A, Bryant D, Getgood AM. Lateral extra-articular tenodesis reduces rotational laxity when combined with anterior cruciate ligament reconstruction: A systematic review of the literature. *Arthrosc J Arthrosc Relat Surg* 2015;31:2022-2034.
 14. Batailler C, Lustig S, Reynaud O, Neyret P, Servien E. Complications and revision surgeries in two extra-articular tenodesis techniques associated to anterior cruciate ligament reconstruction. A case-control study. *Orthop Traumatol Surg Res* 2018;104:197-201.
 15. Cordasco FA, Black SR, Price M, et al. Return to sport and reoperation rates in patients under the age of 20 after primary anterior cruciate ligament reconstruction: Risk profile comparing 3 patient groups predicated upon skeletal age. *Am J Sports Med* 2019;47:628-639.
 16. Devitt BM, Bouguennec N, Barfod KW, Porter T, Webster KE, Feller JA. Combined anterior cruciate ligament reconstruction and lateral extra-articular tenodesis does not result in an increased rate of osteoarthritis: A systematic review and best evidence synthesis. *Knee Surg Sport Traumatol Arthrosc* 2017;25:1149-1160.