Technical Note

The Modified Ellison Technique: A Distally Fixed Iliotibial Band Transfer for Lateral Extra-articular Augmentation of the Knee

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Abstract: Lateral extra-articular augmentation (LEA) of anterior cruciate ligament reconstructions significantly reduces graft failure rates. Currently, proximally fixed LEA procedures are popular techniques. However, there are concerns about these techniques regarding anterior cruciate ligament tunnel collision, kinematic overconstraint, and increasing lateral-compartment contact forces. These issues are potentially avoided by the modified Ellison procedure, which is a distally fixed LEA technique. This article describes the surgical details of this easily reproducible technique.

Historically, lateral extra-articular augmentation (LEA) procedures were used as a primary treatment for the surgical management of anterior cruciate ligament (ACL) deficiency prior to the routine use of intra-articular ACL reconstruction (ACLR).[1] Despite the fact that ACLR is now considered the gold standard in restoring knee stability, there are still some concerns regarding the high rates of reinjury, especially in younger athletes who participate in pivoting sports.[2-5] Residual laxity has been shown to correlate with decreased athletic performance, a reduced rate of return to sports, and a higher incidence of ACL graft rupture.[6-8] The addition of an LEA procedure to ACLR has been shown to diminish anterolateral rotational laxity of the knee and has been found to be protective of the ACL graft.[1,9,10] Getgood et al.[11] have shown in a randomized clinical trial that the addition of an LEA procedure (modified Lemaire procedure) in the setting of an ACLR can significantly reduce graft failure rates when compared with ACLR alone (4% vs 11%). This study's findings are supported by the results of other prospective comparative studies that have shown reduced numbers of ACL graft ruptures in the setting of additional LEA procedures.[12,13]

A variety of LEA techniques have been proposed and modified over the years.[14] Most use a strip of the iliotibial band (ITB) that remains attached to the Gerdy tubercle, which is passed either deep or superficial to the lateral collateral ligament (LCL) and fixed to a point on the lateral aspect of the distal femur. The modified Lemaire procedure and MacIntosh procedure are examples.[15] The most common concern with these techniques is overconstraint of the lateral compartment, as well as the potential risk of accelerated chondral wear and development of osteoarthritis.[16,17] In addition, when this technique is combined with an intra-articular ACLR, there is a risk of tunnel convergence between the femoral socket of the ACL graft and the proximal fixation of the LEA.[18] An alternative, distally fixed ITB transfer, originally described by Ellison,[19] has also been used. The proposed advantage of this technique is that it provides control of anterolateral rotatory laxity but avoids excessive lateral-compartment constraint.[20,21] In addition, this procedure circumvents the issue of compromising the femoral tunnel in ACLR by virtue of its distal fixation. This purpose of this article is to describe the surgical technique of the modified Ellison procedure—a distally fixed LEA technique (Video 1).

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Fig 1. The patient is placed supine on a surgical table with the left knee positioned in 70° of flexion using a foot rest and a lateral bolster. A laterally based incision is made from the Gerdy tubercle to 2 to 3 cm proximal to the proximal insertion of the lateral collateral ligament. After exposure of the iliotibial band (ITB), a 1-cm-wide strip of the ITB (asterisk) is harvested 1 cm anterior to the posterior border of the ITB. The graft is dissected off the Gerdy tubercle with a sliver of bone or just the periosteum and mobilized proximally.

Surgical Technique

Indications

The modified Ellison procedure is used in the primary ACLR setting in patients deemed at high risk of ACL graft rupture. Because there are no definitive indications for an LEA in the current literature, the decision to perform this procedure is made in consultation with the patient after discussion of his or her risk of reinjury after ACLR.[8,22-24] The specific risk factors that are taken into consideration are as follows: age younger than 20 years at the time of ACLR, previous contralateral ACLR, positive family history of ACL rupture (first-degree relative, i.e., parent or sibling), generalized joint hypermobility (Beighton score $\geq$ 5), grade 3 pivot-shift test in the consulting room, and patient participation in sports at an elite or professional level.[25] In addition, this procedure is commonly performed in the setting of revision ACLR.

Patient Positioning

The patient is placed supine on a surgical table. A foot rest and lateral thigh post are used so that the knee rests in 70° of flexion. The surgical extremity is prepared and draped in a standard fashion, with the use of a tourniquet left to the surgeon's discretion.

Operative Sequence

The modified Ellison procedure is carried out toward the end of the ACLR procedure. The ACL graft is passed and fixed in the femoral tunnel. Afterward, the graft is tensioned with cyclical full range of movement of the knee but is not fixed on the tibial side until the modified Ellison procedure has been completed. This avoids altering the tension of the ACL graft with any change in tibial rotation that may occur as a result of the modified Ellison procedure.

ITB Harvest

A laterally based incision is made from the Gerdy tubercle to 2 to 3 cm proximal to the proximal insertion of the LCL. The posterior border of the ITB is identified, and the graft is harvested 1 cm anterior to this anatomic landmark. A 10-mm-wide graft is harvested in line with the ITB fibers (Fig 1). The graft remains attached to the ITB proximally. The ITB is directly superficial to the LCL, so care must be taken to avoid injury to the LCL as the graft is harvested by sharp dissection. Distally, the graft can be sharply dissected off the Gerdy tubercle with a sleeve of periosteum. As an alternative, a small bone wafer can be harvested with the distal graft with the use of a small osteotome. It is important that the bone harvested is not too large because it can impede passage of the graft deep to the LCL.

LCL Dissection and Graft Passage

The next step involves identifying the LCL, which can be difficult to visualize (Table 1). To assist in palpation of the LCL, the knee is placed in the figure-of-4 position, which places the ligament under tension in the defect created by the ITB graft harvest (Fig 2). Once the origin of the LCL and the borders of the ligament have been identified, sharp dissection is performed on the anterior and posterior aspects of the LCL. This facilitates the passage of a blunt hemostat forceps deep to the ligament from posterior to anterior (Fig 3A). It is often necessary to dilate the soft-tissue tunnel by opening and closing the jaws of the forceps. However, care must be taken to avoid excessive dilation to avoid injury to the LCL origin on the femoral epicondyle. The placement of the forceps is then reversed, and the forceps is used to grasp the distal end of the graft and pass it from

Table 1. Pearls and Pitfalls

Pearls
The posterior border of the ITB should be identified before harvesting of the graft 1 cm anterior to this landmark.
The knee should be placed in the figure-of-4 position to help palpate and identify the LCL in the ITB defect.
The proximal ITB defect should be left open to avoid lateral patellofemoral constraint.
Pitfalls
Fixing the ACL graft on the tibial side prior to completion of the modified Ellison procedure can potentially lead to an alteration in ACL graft tension.
Overly deep dissection of the ITB graft can cause damage to the underlying LCL.
Inadequate dissection of the soft-tissue tunnel deep to the LCL can cause difficulty with graft passage.
Overly aggressive dilation of the soft-tissue tunnel can damage the LCL femoral origin.

ACL, anterior cruciate ligament; ITB, iliotibial band; LCL, lateral collateral ligament.

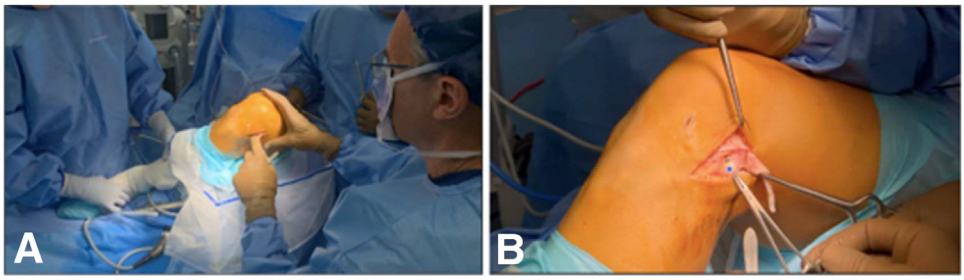

Fig 2. (A) After harvest of a 1-cm-wide strip of the iliotibial band released distally at the Gerdy tubercle through a lateral incision, the left knee is placed in the figure-of-4 position to allow palpation of the lateral collateral ligament in the 1-cm defect created in the iliotibial band. (B) The anterior and posterior margins of the lateral collateral ligament (asterisk) are exposed, and a tunnel is created to allow easy passage of the graft medial to the ligament. A blunt hemostat is used to dilate the soft-tissue tunnel.

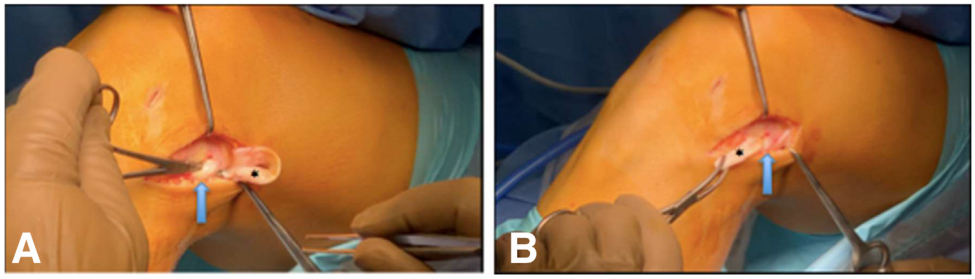

Fig 3. (A) The hemostat is passed under the lateral collateral ligament (LCL) (arrow) of the left knee through a soft-tissue tunnel created with sharp and blunt dissection anterior and posterior to the LCL to retrieve the distal end of the iliotibial band graft (asterisk). (B) The graft (asterisk) is then passed deep to the LCL (arrow), with care taken to avoid twisting to maintain its natural orientation.

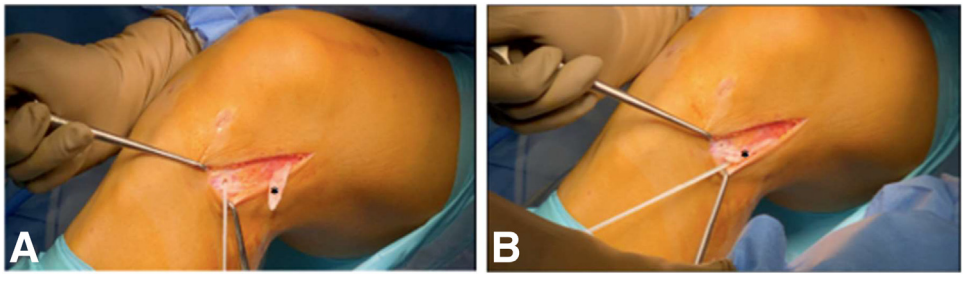

Fig 4. (A) After passage of the 1-cm strip of the iliotibial band (ITB; asterisk) deep to the lateral collateral ligament of the left knee, the site from where the distal insertion of the ITB was released from the Gerdy tubercle is exposed. A double-loaded suture anchor is placed in the center of the Gerdy tubercle from where the ITB graft was harvested. (B) Each suture is passed through the distal end of the ITB graft (asterisk) to restore the distal end on the ITB to its original position.

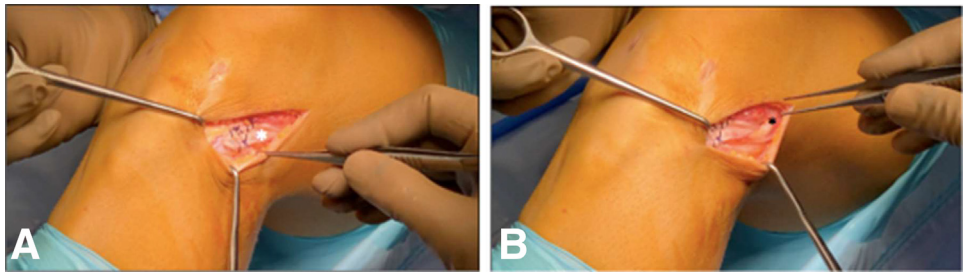

Fig 5. (A) The distal aspect of the iliotibial band defect (asterisk) of the left knee is closed with interrupted mattress sutures anteriorly and posteriorly. (B) The proximal aspect of the defect (asterisk) is left open unless there is muscle herniation, in which case it is closed with a mattress suture to the level of the lateral collateral ligament.

Table 2. Advantages and Disadvantages of Modified Ellison Technique Compared With Proximally Fixed LEA Procedures With Distal ITB Defect Closure

Advantages
ACL femoral tunnel convergence is avoided.
ITB graft tensioning is reproducible while overconstraint of the lateral and patellofemoral compartments is avoided.
The knee can be positioned in any degree of flexion or rotation during final fixation.
Disadvantages
Knot prominence can occur at the distal fixation site.
Potential soft-tissue herniation can occur through the ITB defect.

ACL, anterior cruciate ligament; ITB, iliotibial band; LEA, lateral extra-articular augmentation.

proximal to distal. It is important to avoid twisting of the graft during passage through the soft-tissue tunnel.

Graft Fixation

The site of harvest of the ITB from the Gerdy tubercle is identified. A bone trough is made using a small osteotome and rongeur (bone nibbler). This facilitates clear visualization for the insertion point of the bone anchor and reduces the prominence of the suture knots. A double-loaded suture anchor (3.5-mm Twinfix suture anchor; Smith & Nephew, Memphis, TN) is inserted in the center of the donor site of the Gerdy tubercle. Each of the 4 suture ends is passed through the distal end of the graft, either through the periosteum or a sliver of bone at appropriate distances to avoid knot pull-through (Fig 4). It is important to reduce the graft back to the same position from which it was harvested. The knee should be positioned to facilitate this, but the degree of flexion and rotation is not important because the graft remains attached to the ITB proximally rather than to the femur directly. The graft is secured with alternating half-hitch knots. The repair is reinforced anteriorly and posteriorly with No. 2-0 Vicryl mattress stitches (Johnson & Johnson, New Brunswick, NJ) (Fig 5).

ITB Defect Closure

Closure of the ITB defect has not been shown to have any impact on the degree of lateral rotatory constraint of the knee.[20] However, the defect is left open because there is concern about the effect it may have on the compartment pressure of the lateral facet of the patella.[26] If there is concern about muscle herniation as a result of harvesting the ITB above the level of the vastus lateralis, a horizontal mattress suture using No. 1-Vicryl (Johnson & Johnson) can be used to reapproximate the proximal edges of the ITB. The procedure is completed by final ACL graft tensioning, tibial fixation, and closure of skin incisions.

Rehabilitation

The addition of a modified Ellison procedure does not change the rehabilitation protocol from that of routine ACLR. Typically, this involves immediate weight bearing of the operative extremity with a focus on regaining full extension and quadriceps function during the initial recovery. This initial phase can be more difficult after the addition of a modified Ellison procedure augmentation owing to pain and swelling at the surgical site. Beyond this initial phase, rehabilitation proceeds on a routine basis.

Discussion

LEA procedures have been shown to reduce clinical ACLR failure rates.[24-26] The modified Ellison procedure is an easily reproducible procedure that has potential advantages compared with proximally fixed LEA (Table 2). In contrast to the modified Lemaire procedure, tensioning of the graft is not a concern with the modified Ellison procedure because the graft is reattached to its harvest site.[14,20] In addition, the knee can be placed in any degree of flexion and/or rotation without concern about altering tension in the lateral and patellofemoral compartments.[14,26] A technical challenge when performing a proximally fixed LEA is avoiding convergence with the femoral ACL tunnel.[18,27] The modified Ellison technique avoids this technical hurdle because the LEA is distally fixed to the tibia while remaining in continuity with the native ITB proximally.

The original operative technique of a distal ITB transfer was described by Ellison[19] in 1979. At that time, it was used in isolation for the treatment of ACL-deficient knees with anterolateral rotatory instability. The initial technique described was more extensive than the modified version that has been outlined in this article. The theory behind the effectiveness of this technique, at the time of its inception, was that the broad-based shape of the strip of ITB preserves the blood supply to the fascia and the dynamic pull of the tensor fasciae latae and part of the gluteus maximus.[19] This theory was disputed by Kennedy et al.[28] in 1978, who reported relatively poor results using this technique in isolation or combined with other reconstructive procedures. Further studies by Lipscomb and Anderson[29] and Lipscomb et al.[30] reported on a series of 75 knees with chronic ACL deficiency that were treated with a semitendinosus and gracilis intra-articular ACLR, posteromedial and lateral capsular ligament reefing, and an Ellison LEA procedure. The authors contended that the distally fixed LEA procedure did not adequately prevent anterolateral instability. However, it is important to note that these ACL injuries were chronic and no objective evidence to support this assertion was presented in their studies.

The modified Ellison procedure has been the topic of biomechanical investigation. Devitt et al.[20] and Neri et al.[21] have biomechanically shown that this technique restores the kinematics close to normal in an anterolateral capsule–sectioned cadaveric model while

avoiding overconstraint of internal rotation of the tibia. In addition, the modified Ellison technique does not increase lateral-compartment contact forces when compared with the modified Lemaire and modified MacIntosh procedures.[17]

LEA can reliably reduce rotational laxity in the setting of primary and revision ACLR. Being a simpler LEA procedure, the modified Ellison technique can potentially mitigate ACL graft ruptures in the high-risk patient population while avoiding the technical challenges and potential overconstraint associated with proximally fixed LEA procedures.

References

1. Chambat P, Guier C, Sonnery-Cottet B, Fayard JM, Thaunat M. The evolution of ACL reconstruction over the last fifty years. *Int Orthop* 2013;37:181-186.
2. Song GY, 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. *Arthroscopy* 2016;32:898-905.
3. Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2827-2832.
4. Magnussen RA, Lawrence JT, West RL, Toth AP, Taylor DC, Garrett WE. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy* 2012;28:526-531.
5. Snaebjornsson T, Svantesson E, Sundemo D, et al. Young age and high BMI are predictors of early revision surgery after primary anterior cruciate ligament reconstruction: A cohort study from the Swedish and Norwegian knee ligament registries based on 30,747 patients. *Knee Surg Sports Traumatol Arthrosc* 2019;27:3583-3591.
6. Hetsroni I, van-Stee M, Marom N, et al. Factors associated with improved function and maintenance of sports activities at 5 to 10 years after autologous hamstring ACL reconstruction in young men. *Orthop J Sports Med* 2017;5. 2325967117700841.
7. Magnussen RA, Reinke EK, Huston LJ, et al. Effect of high-grade preoperative knee laxity on 6-year anterior cruciate ligament reconstruction outcomes. *Am J Sports Med* 2018;46:2865-2872.
8. Sonnery-Cottet B, Barbosa NC, Vieira TD, Saithna A. Clinical outcomes of extra-articular tenodesis/anterolateral reconstruction in the ACL injured knee. *Knee Surg Sports Traumatol Arthrosc* 2018;26:596-604.
9. Marom N, Ouanezar H, Jahandar H, et al. Lateral extra-articular tenodesis reduces anterior cruciate ligament graft force and anterior tibial translation in response to applied pivoting and anterior drawer loads. *Am J Sports Med* 2020;48:3183-3193.
10. Devitt BM, Bell SW, Ardern CL, et al. The role of lateral extra-articular tenodesis in primary anterior cruciate ligament reconstruction: A systematic review with meta-analysis and best-evidence synthesis. *Orthop J Sports Med* 2017;5:2325967117731767.
11. Getgood AMJ, Bryant DM, Litchfield R, et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-Year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285-297.
12. Castoldi M, Magnussen RA, Gunst S, et al. A randomized controlled trial of bone-patellar tendon-bone anterior cruciate ligament reconstruction with and without lateral extra-articular tenodesis: 19-Year clinical and radiological follow-up. *Am J Sports Med* 2020;48:1665-1672.
13. 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.
14. Inderhaug E, Stephen JM, Williams A, Amis AA. Anterolateral tenodesis or anterolateral ligament complex reconstruction: Effect of flexion angle at graft fixation when combined with ACL reconstruction. *Am J Sports Med* 2017;45:3089-3097.
15. Slette EL, Mikula JD, Schon JM, et al. Biomechanical results of lateral extra-articular tenodesis procedures of the knee: A systematic review. *Arthroscopy* 2016;32:2592-2611.
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 Sports Traumatol Arthrosc* 2017;25:1149-1160.
17. Neri T, Cadman J, Beach A, et al. Lateral tenodesis procedures increase lateral compartment pressures more than anterolateral ligament reconstruction, when performed in combination with ACL reconstruction: A pilot biomechanical study. *J ISAKOS* 2021;6:66-73.
18. Jaecker V, Ibe P, Endler CH, Pfeiffer TR, Herbort M, Shafizadeh S. High risk of tunnel convergence in combined anterior cruciate ligament reconstruction and lateral extra-articular tenodesis. *Am J Sports Med* 2019;47:2110-2115.
19. Ellison AE. Distal iliotibial-band transfer for anterolateral rotatory instability of the knee. *J Bone Joint Surg Am* 1979;61:330-337.
20. Devitt BM, Lord BR, Williams A, Amis AA, Feller JA. Biomechanical assessment of a distally fixed lateral extra-articular augmentation procedure in the treatment of anterolateral rotational laxity of the knee. *Am J Sports Med* 2019;47:2102-2109.
21. Neri T, Dabirrahmani D, Beach A, et al. Different anterolateral procedures have variable impact on knee kinematics and stability when performed in combination with anterior cruciate ligament reconstruction. *J ISAKOS* 2021;6:74-81.
22. Getgood A, Brown C, Lording T, et al. The anterolateral complex of the knee: Results from the International ALC Consensus Group Meeting. *Knee Surg Sports Traumatol Arthrosc* 2019;27:166-176.
23. Getgood A, Bryant D, Firth A, Stability G. The stability study: A protocol for a multicenter randomized clinical trial comparing anterior cruciate ligament reconstruction

with and without lateral extra-articular tenodesis in individuals who are at high risk of graft failure. *BMC Musculoskelet Disord* 2019;20:216.
24. Getgood A, Hewison C, Bryant D, et al. No difference in functional outcomes when lateral extra-articular tenodesis is added to anterior cruciate ligament reconstruction in young active patients: The stability study. *Arthroscopy* 2020;36:1690-1701.
25. Feller JA, Devitt BM, Webster KE, Klemm HJ. Augmentation of primary ACL reconstruction with a modified Ellison lateral extra-articular tenodesis in high-risk patients: A pilot study. *Orthop J Sports Med* 2021;9:23259671211021351.
26. Inderhaug E, Stephen JM, Williams A, Amis AA. Effect of anterolateral complex sectioning and tenodesis on patellar kinematics and patellofemoral joint contact pressures. *Am J Sports Med* 2018;46:2922-2928.
27. Katakura M, Koga H, Nakamura T, et al. Biomechanical effects of additional anterolateral structure reconstruction with different femoral attachment sites on anterior cruciate ligament reconstruction. *Am J Sports Med* 2019;47:3373-3380.
28. Kennedy JC, Stewart R, Walker DM. Anterolateral rotatory instability of the knee joint. An early analysis of the Ellison procedure. *J Bone Joint Surg Am* 1978;60:1031-1039.
29. Lipscomb AB, Anderson AF. Tears of the anterior cruciate ligament in adolescents. *J Bone Joint Surg Am* 1986;68:19-28.
30. Lipscomb AB, Johnston RK, Snyder RB. The technique of cruciate ligament reconstruction. *Am J Sports Med* 1981;9:77-81.