Combined Anterior Cruciate Ligament Reconstruction and Lateral Extra-Articular Tenodesis: The "Over-the-Top" Technique

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Background: The anterior cruciate ligament (ACL) is a primary restraint to anteroposterior as well as rotatory knee laxity. In case of concomitant lesion of menisci or other ligamentous structures, further dynamic instability is encountered. A lateral extra-articular tenodesis (LET) augmentation has been proposed by the Authors to treat or prevent residual laxity.

Indications: ACL reconstruction is recommended in young athletes involved in pivoting sports, non-contact pivoting injuries, high-grade pivot shift, deep notch sign and double bone bruise, meniscal loss, and revision of previous bone-patellar tendon-bone autograft.

Technique Description: A 2 to 3 cm oblique incision is made over the pes anserinus. Gracilis and semitendinosus tendons are harvested with their attachment preserved and sutured together. Tibial tunnel is reamed after positioning of a guide pin. A wire-loop passer is directed from the tibial tunnel to the anteromedial portal. A 2 to 3 cm longitudinal incision is made superior-laterally, the ileotibial band is divided and retracted anteriorly. A suture-loop is retrieved from the lateral incision through the anteromedial portal with a curved Kelly clamp. The suture is placed into the wire-loop and retrieved with it from the tibial tunnel. The graft is retrieved from the lateral incision, tensioned with the knee at 70° to 90° of flexion and foot in neutral rotation and secured with 2 staples to the femur. A 1-cm skin incision is performed just below the Gerdy tubercle. The graft is retrieved from this incision below the fascia with a small Kelly clamp, tensioned and secured with a staple. The iliotibial tract defect is closed.

Results: At long-term follow-up, a revision rate of 3% has been reported, while patient-reported outcome measures (PROMs) were excellent. At very-long-term follow-up, most patients were still involved in sports with a very low rate of positive Lachman and pivot shift tests. No overconstraint and lateral osteoarthritis were encountered. Medial osteoarthritis was related only to medial meniscectomy.

Discussion/Conclusion: The ACL reconstruction plus LET over-the-top technique is a safe and reliable surgery with a low rate of reoperations and peri-operative complications at very-long-term follow-up.

Patient Consent Disclosure Statement: The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

Keywords: anterior cruciate ligament reconstruction; hamstrings; over-the-top; lateral extra-articular reconstruction; arthroscopy; ACL-R; OTT; LET

VIDEO TRANSCRIPT

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These are the disclosures of the authors.

Present technique represents the Gold Standard for the Authors since 1993. In fact, more than 6000 patients have been operated with this technique that includes hamstrings harvesting maintaining the tibial attachment; no execution of the femoral tunnel, over-the-top fixation of the graft with metal staples and lateral extra-articular tenodesis (LET) using the remnant of the graft.[7]

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From the anatomical point of view, the over-the-top represents the femoral insertion for this technique. In fact, the over-the-top position is close to the insertion of direct fibers of the anterior cruciate ligament (ACL) that share nearly 90% of the load bearing of the whole ligament. The high insertion has lower failure rate with respect to the central insertion according to several studies in literature.[6,8,9]

From a biomechanical point of view, the effect of the LET has been tested in vivo with navigation system and lateral plasty has been demonstrated to reduce the translation of the lateral compartment during the pivot shift.[1]

The distal insertion of the hamstring tendons has been demonstrated to be rich in arteries, nerves, and mechanoreceptors. Therefore, its preservation during ACL reconstruction improves graft healing compared to techniques where the graft is completely detached.[2,10]

Indications of the present technique are young athletes involved in pivoting sports, non-contact pivoting injuries, high-grade pivot shift, deep notch sign and double bone bruise, medial or lateral meniscal loss, and revision of previous bone-patellar tendon-bone autograft.

To describe this technique, we present the case of a 14-year-old female agonist dancer with open femoral physis and closed tibial physis.

The patient had a non-contact ACL rupture 4 weeks before surgery with signal alteration of the ACL and double bone bruise in the lateral compartment at the magnetic resonance imaging (MRI).

Patient positioning includes supine position, lateral side support to allow the joint stress, a pneumatic tourniquet, spinal anesthesia, and antibiotic prophylaxis.

The instrumentation does not include any particular device, just a basic set for arthroscopic surgery.

At manual evaluation are noted a 3 plus Lachman test with soft end point; 2 plus anterior drawer test and a pivot shift positive for gross abnormality compared with the contralateral side, even at the accelerometer evaluation.

Skin landmarks can be optionally marked. The high antero-lateral portal and the low anteromedial portal are performed under arthroscopic guidance. The remnant of the ACL is debrided, especially at the proximal part and at the level of the intercondylar notch to prepare the over-the-top position.

An oblique incision is performed at the level of the pes anserinus, 2 fingers below and 1 finger medially to the anterior tuberosity. The sartorius fascia is opened, and the hamstring tendons are isolated. Care should be paid to break the adhesions between the tendons and the medial gastrocnemius. An open tendon stripper is used to harvest the gracilis first and then the semitendinosus tendons. It is useful to use a scissor and a blunt dissection with a finger to break and remove all the adhesions of the tendons and to maximize the length of the grafts.

Partial release of the insertion of the pes anserinus is performed: The tendons are left attached to the tibia and then cleaned from the muscular tissues. A non-absorbable n.2 suture is used to whipstitch the tendons in a Krakow fashion, preparing nearly 5 to 10 cm of them. A K-wire is inserted to the same incision directed to the tibial footprint of the ACL, and a tunnel is drilled with a 7 or 8 mm of diameter. The shaver is then used to clean the tunnel and the remnants, to smooth the passage of the graft. A wire-loop is inserted to the tibial tunnel and retrieved with forceps from the anteromedial portal.

The skin landmarks for the over-the-top approach are the lateral epicondyle, the posterior margin of the iliotibial (IT) band, and the tip of the fibula. A 3 to 5 cm incision is performed in line with the IT band and proximal to the lateral epicondyle. The subcutaneous tissue is carefully dissected, and a careful hemostasis is performed. After placing a retractor, an incision in line with the fibers of the IT band is performed 1 cm from its posterior margin. The intermuscular septum is divided with the electrocautery, and a blunt dissection is performed with a finger.

A curved Kelly clamp is passed from the anteromedial portal and inserted into the notch piercing the posterior capsule of the joint. A suture-loop is inserted through the lateral incision and retrieved with the Kelly clamp from the anteromedial portal. The suture-loop is passed through the metal wire and retrieved from the tibial tunnel. Finally, the graft is passed through the tibial tunnel, inside the joint and outside from the lateral incision.

The tourniquet can be optionally removed to perform hemostasis at the level of the lateral femur and the geniculate artery, to avoid any bleeding. Two 8-mm metal staples are used to secure the graft at the level of the over-the-top position, maintaining maximum tension and paying attention not to cut it. Fixation is performed with the knee at 70° to 90° of flexion and neutral rotation of the foot.

Finally, an incision at the level of the Gerdy tubercle is performed and a curved Kelly clamp is inserted beneath the IT band. The remnant part of the graft is retrieved and secured with a 6-mm metal staple to perform a LET. In this case, a knot with the remnant suture is performed to avoid the slippage of the graft beneath the staple.

The postoperative rehabilitation protocol includes free range of motion exercises since the first day. From the second to the fourth week, restricted weightbearing, active mobilization, and proprioceptive exercises are initiated. From the first to the third month, full weightbearing is allowed and also active mobilization and strengthening exercises. From the third to sixth month, functional rehabilitation and return to training are allowed. Sport-specific training and return to sport are allowed after 6 post-operative months according to the type of sport performed by the patient.

The advantages of this technique include a reliable graft positioning and orientation due to the lack of the femoral tunnel, a "quasi-anatomical" reconstruction because of the over-the-top position close to the insertion of the direct fibers of the ACL, no risk of cyclops lesions or lack of extension due to the limited size of the graft (that avoids impingement with the notch), no tunnel enlargement in the tibia, because there are no hardware present inside the tibial tunnel, stable and immediate cortical fixation both to the tibial side with the remnant of the graft and also to the femur when staples are used and biological preservation of the neurovascular supply of the graft.

Potential complications include a short graft that does not allow to perform the LET, graft detachment from the tibial insertion, geniculate artery bleeding, IT band irritation due

to the metal staples used to fixate the graft, and popliteal artery injury, even if this is a very rare complication.

The present technique has a vast literature of clinical results from short-term to very-long-term follow-up.

First, the safety of the technique has been tested in 2559 consecutive patients, assessing the 90-day causes of readmission. The superficial infection rate was 0.63%, with higher risk in female sex. The deep infection rate was 0.55%, especially in patients with meniscal treatment. Overall rate of readmission in the first 3 months was 2.27%.[3]

Regarding ligament healing, a good signal of the graft has been reported since the first post-operative month, with no big difference between 1, 6, and 12 months, indicating an early graft maturation which is maintained up to long-term follow-up.[2]

The 10 years failure rate has been investigated in 244 consecutive patients with 10 years minimum follow-up, with only 3% of revision ACL (of the overall 13% of reoperations).[4]

The 10 years subjective patient-reported outcome measures (PROMs) have been assessed with 73% of patients reporting to have excellent results with the worst Knee Injury and Osteoarthritis Outcome Score (KOOS) sport subscale in female patients and patients with Outerbridge grade $>$ II.[5]

The very-long-term follow-up has been assessed at a mean of 24 years postoperative in 29 patients with 86% of patients reporting International Knee Documentation Committee (IKDC) grade A or B, 62% with good or excellent Lysholm, and 41% still involved in sport. Medial osteoarthritis was present only in patients with medial meniscectomy, and there was no increase on lateral osteoarthritis despite the use of LET.[11]

To conclude, the present technique has a solid biomechanical rationale, potential biological role of graft insertion preservation, low revision rate at long-term follow-up, limited number of reoperations, good long-term PROMs and sport activity, and low degree of osteoarthritis mainly related to meniscectomy.

REFERENCES

1. Bignozzi S, Zaffagnini S, Lopomo N, Martelli S, Iacono F, Marcacci M. Does a lateral plasty control coupled translation during anteroposterior stress in single-bundle ACL reconstruction? An in vivo study. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(1):65-70.
2. Grassi A, Casali M, Macchiarola L, et al. Hamstring grafts for anterior cruciate ligament reconstruction show better magnetic resonance features when tibial insertion is preserved. *Knee Surg Sports Traumatol Arthrosc*. 2021;29(2):507-518.
3. Grassi A, Costa GG, Cialdella S, Lo Presti M, Neri MP, Zaffagnini S. The 90-day readmission rate after single-bundle ACL reconstruction plus LET: analysis of 2,559 consecutive cases from a single institution. *J Knee Surg*. 2021;34(9):978-986.
4. Grassi A, Macchiarola L, Lucidi GA, et al. More than a 2-fold risk of contralateral anterior cruciate ligament injuries compared with ipsilateral graft failure 10 years after primary reconstruction. *Am J Sports Med*. 2020;48(2):310-317.
5. Grassi A, Macchiarola L, Lucidi GA, et al. Ten-year survivorship, patient-reported outcome measures, and patient acceptable symptom state after over-the-top hamstring anterior cruciate ligament reconstruction with a lateral extra-articular reconstruction: analysis of 267 consecutive cases. *Am J Sports Med*. 2021;49(2):374-383.
6. Lubowitz JH. Anatomic ACL reconstruction produces greater graft length change during knee range-of-motion than transtibial technique. *Knee Surg Sports Traumatol Arthrosc*. 2014;22(5):1190-1195.
7. Marcacci M, Zaffagnini S, Iacono F, Neri MP, Loreti I, Petitto A. Arthroscopic intra- and extra-articular anterior cruciate ligament reconstruction with gracilis and semitendinosus tendons. *Knee Surg Sports Traumatol Arthrosc*. 1998;6(2):68-75.
8. Pearle AD, McAllister D, Howell SM. Rationale for strategic graft placement in anterior cruciate ligament reconstruction: I.D.E.A.L. Femoral tunnel position. *Am J Orthop*. 2015;44(6):253-258.
9. Rahr-Wagner L, Thillemann TM, Pedersen AB, Lind MC. Increased risk of revision after anteromedial compared with transtibial drilling of the femoral tunnel during primary anterior cruciate ligament reconstruction: results from the Danish Knee Ligament Reconstruction Register. *Arthroscopy*. 2013;29(1):98-105.
10. Zaffagnini S, Golanò P, Farinas O, et al. Vascularity and neuroreceptors of the pes anserinus: anatomic study. *Clin Anat N Y N*. 2003;16(1):19-24.
11. Zaffagnini S, Marcheggiani Muccioli GM, Grassi A, et al. Over-the-top ACL reconstruction plus extra-articular lateral tenodesis with hamstring tendon grafts: prospective evaluation with 20-year minimum follow-up. *Am J Sports Med*. 2017;45(14):3233-3242.