The MacIntosh Procedure

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26.1 Introduction

Like many pioneers in surgery, Dr. D.L. MacIntosh developed his lateral reconstruction for the anterior cruciate ligament deficient-knee out of necessity. During his tenure as the orthopedic surgeon for varsity athletes at the University of Toronto in the late 1960s, most of his colleagues were focused on addressing meniscal pathology alone, which did nothing to improve symptoms of recurrent instability. Aside from intra-articular pathology, much attention at the time was focused on the concept of medial and anterolateral rotatory instability of the knee [9, 13]. Only in 1972 was Dr. MacIntosh able to reproduce the mechanism of an ACL injury by a physical exam maneuver that is now widely known as the "pivot shift test" [4]. This clinical examination produces an anterior subluxation of the lateral tibial plateau under the lateral femoral condyle when the limb is supported in full extension with a valgus force applied. Subsequent reduction is felt as the knee reaches 30–50° of flexion. Anatomically, the iliotibial band shifts from having extensor function anterior to the flexion-extension axis when the knee is subluxed to a flexor function posterior to the axis when the knee is reduced [4].

His desire to understand the biomechanics contributing to ACL ruptures in his athletes naturally led to the development of a method to prevent recurrent instability after injury. Dr. John Cameron, one of Dr. MacIntosh's best known fellows, describes how Dr. MacIntosh spoke of the need to "tether the tibia" to avoid the anteromedial to posterolateral displacement of the tibia on the femur [1]. Thus, the MacIntosh anterior cruciate ligament reconstruction was born.

26.1.1 The Evolution of Macintosh Procedure [1]

There have been three well-known iterations of the ACL reconstruction procedure established

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by MacIntosh. All had as their common goal the elimination of the pivot shift phenomenon with or without an anatomic facsimile of the ligament itself. Thus they have often been categorized as "non-anatomic" procedures following the advent of modern intra-articular ACL reconstructive techniques. The MacIntosh I, first outlined in the late 1960s, is an extra-articular reconstruction using the iliotibial band (ITB). The middle third slip of the IT band is detached proximally and transferred deep to the lateral collateral ligament (LCL) and through a subperiosteal window or the lateral intramuscular septum only to be secured back onto the ITB origin (Fig. 26.1). In 1979, Ellison used this concept but modified with a bone block from Gerdy's tubercle rerouted deep to the proximal LCL and securing the iliotibial band anterior to its original insertion [3]. Both of these laterally based reconstructions stabilized rotational control; however in a series of 52 knees, there was residual anterior-posterior laxity in all patients using only this lateral-based technique [10]. The MacIntosh I has provided the foundation for current techniques in anterolateral ligament reconstruction and for similar reasons was found to be more appropriate as an adjunct to eliminate lateral-sided pivot shift since it did not address anterior-posterior laxity [6, 10].

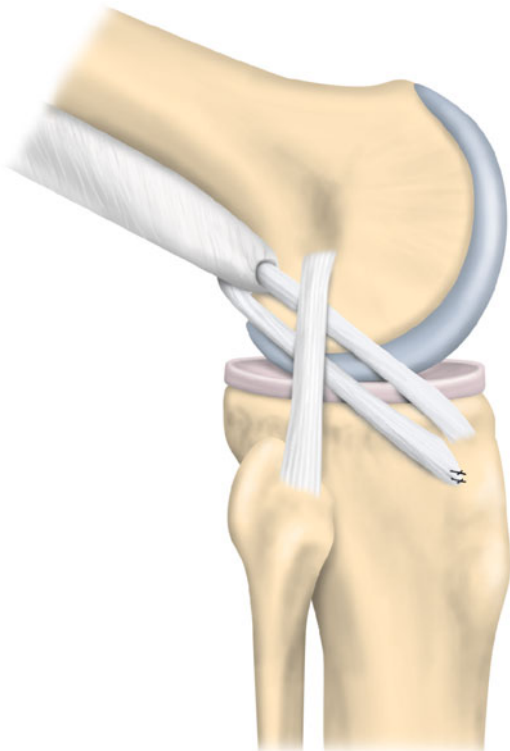


Fig. 26.1 MacIntosh I, lateral extra-articular ligament reconstruction where the iliotibial band graft is passed through the lateral collateral ligament and intermuscular septum and sutured back onto its insertion

Around 1975, MacIntosh refined his original operation with the addition of an intra-articular portion to address the residual A-P laxity noted in some of his previous patients. This became known as the MacIntosh II or lateral substitution over-the-top (LSOT) procedure, which is the technique for which he is most known and described in detail in the section below. The difference in this second iteration includes an intra-articular component where the ITB is passed over the top of the lateral femoral condyle and through a trans-osseous tibial tunnel (Fig. 26.2a, b). This method improved the anterior-posterior laxity experienced by MacI patients, and where his previous patients may have needed screw fixation, MacIntosh described a fixation-free method in his LSOTs by using sutures to secure the reconstruction. It was also noted that patients with concomitant LCL laxity also benefitted from the LSOT as the extra-articular portion of the ITB is weaved through the LCL and ultimately tightened after tensioning.

For acute ACL ruptures where a repair was historically performed, MacIntosh developed a third variation of his procedure called the quadriceps-patellar tendon over the top (QPOT) otherwise known as the MacIntosh III. This method involved using the middle third of the patellar tendon, left attached distally, and extended around the periosteum of the patella and through to the middle third of the quadriceps tendon. This graft was then passed over the top of the lateral femoral condyle as an augment to the acutely ruptured ACL, which was also stitched, passed, and fixated on the lateral femur. Since primary ACL repairs were not performed then, the MacIntosh III procedure consequently grew out of favor (Fig. 26.3).

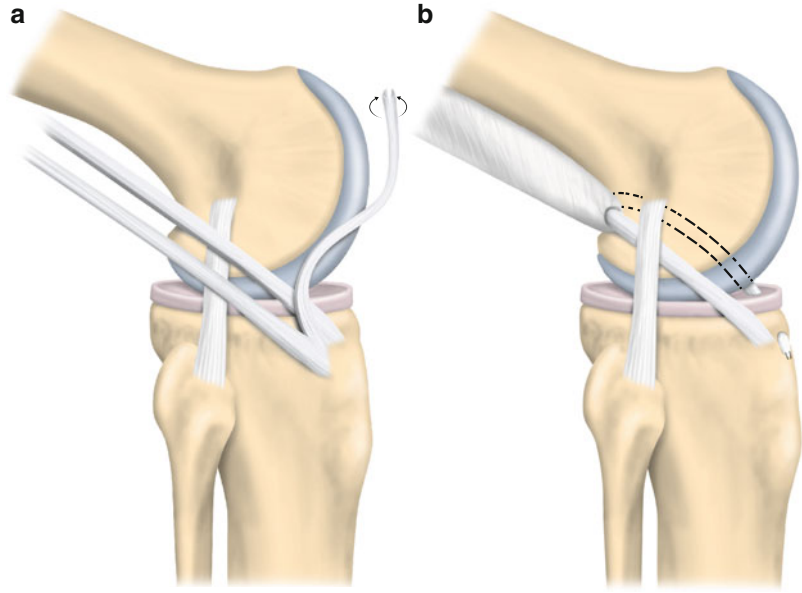


Fig. 26.2 (**a**, **b**) MacIntosh II, iliotibial band graft is passed over the top of the lateral femoral condyle and secured through a tibial tunnel

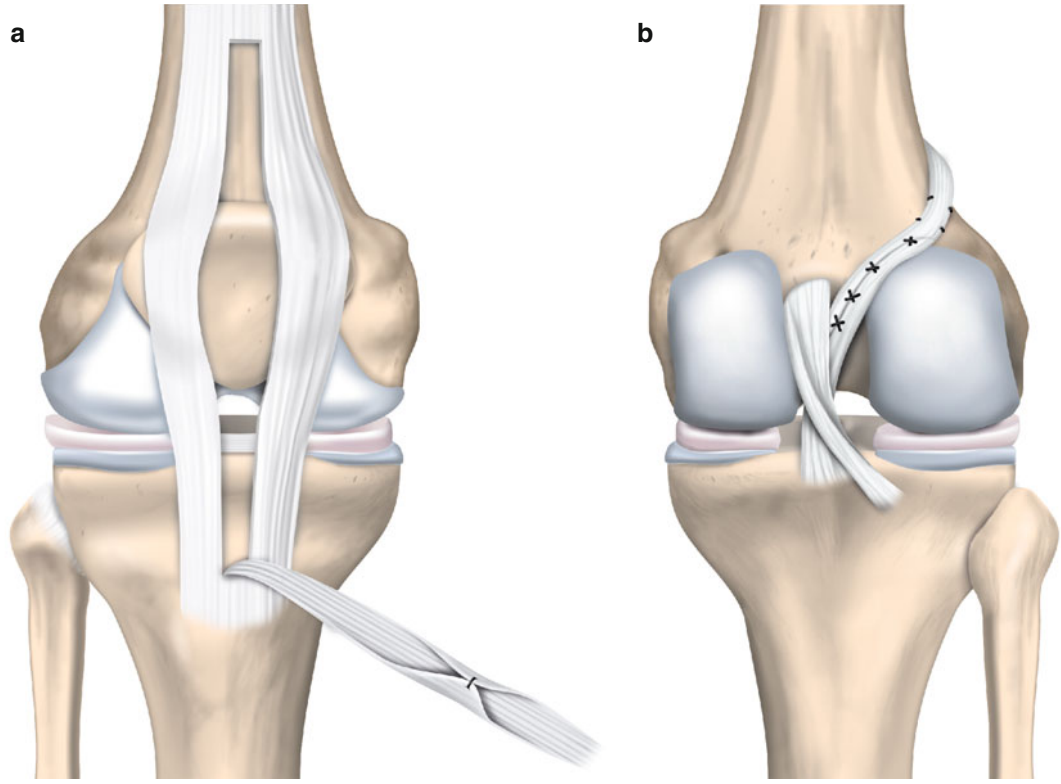


Fig. 26.3 (**a**, **b**) MacIntosh III, quadriceps-patellar tendon over-the-top (QPOT) method usually as an adjunct to an anterior cruciate ligament repair

26.2 Lateral Substitution Over-the-Top Procedure (LSOT) [1, 11]

When it was first described, the indications for the LSOT procedure were focused on individuals with recurrent, symptomatic anterior cruciate ligament instability. The procedure was felt to be ideal for high-demand, contact athletes, athletes who could not wear a brace following injury, and individuals with connective tissue disease and occasionally for failed primary ACL repairs. At present it is occasionally considered in revision cases for patients who have failed anatomic intra-articular ACL reconstructions (in which case it may be used as an augment or a stand-alone procedure) or patients with open growth plates. Surgical goals include a stable, functional, pain-free knee with the restoration of full range of motion and ability to return to sport without the use of a brace if intended.

26.2.1 Surgical Technique for the LSOT or MacIntosh II

Positioning

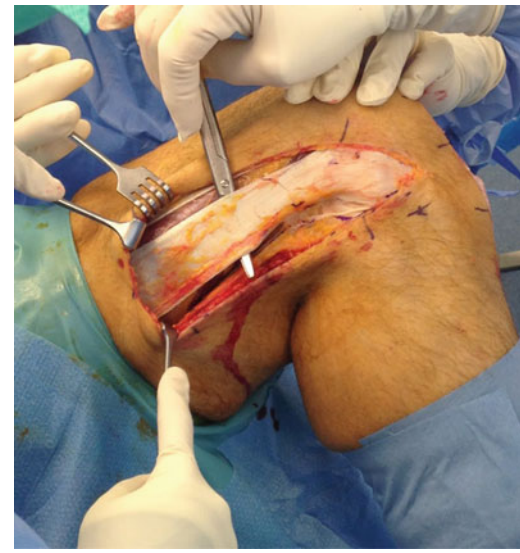
- Patient is positioned supine with an ipsilateral bump underneath the operative limb.
- An examination under general anesthesia is performed to demonstrate the presence of a positive pivot shift test.
- A high tourniquet is placed, inflated, and leg rested on a footplate.

Initial Incision

- Medial parapatellar arthrotomy is carried out to inspect the knee joint and visualize ACL. Meniscal repair/debridement is done at this time.

ITB Graft Harvest

- With the knee in 90° of flexion, a direct lateral incision is extended approximately 6 cm from distal aspect of the lateral femoral condyle to expose the iliotibial band.
  - The middle third of the iliotibial band approximately 6 cm proximal to its insertion site is harvested while leaving it attached distally on Gerdy's tubercle (Fig. 26.4). It should measure approximately 3 cm wide distally and 5 cm wide proximally.
  - The proximal end of the graft is then tubularized with a whipstitch by using a 0-sized, non-absorbable suture and reflected distally (Fig. 26.5).



Figs. 26.4 Iliotibial band graft harvest and detachment proximally

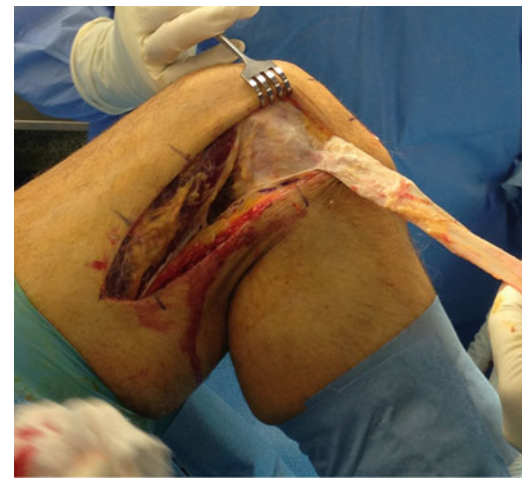


Fig. 26.5 Passage through lateral collateral ligament is developed and marked with Kelly

Tunnel Placement

- The femoral origin of the LCL is isolated and a subperiosteal tunnel from posterior to the femoral origin of the LCL to anterior to the lateral intermuscular septum is created using a curved Kelly (Fig. 26.6).
- A second subperiosteal tunnel is made from posterior to the intermuscular septum into the posterior "over-the-top" area on the femoral condyle (Fig. 26.7).
- The graft is then passed deep to the LCL and through both subperiosteal tunnels into the "over-the-top" region of the intercondylar notch.

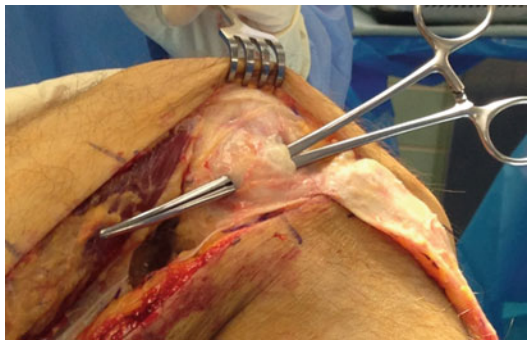


Fig. 26.6 Passage through lateral collateral ligament is developed and marked with Kelly

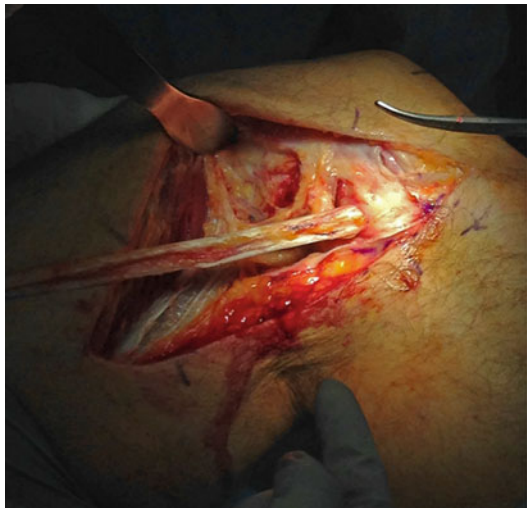


Fig. 26.7 Iliotibial band graft is passed through the lateral collateral ligament tunnel while preparing to pass through intermuscular septum

Tibial Preparation

- A quarter-inch drill hole was made using the 60° guide starting medial to the patellar tendon insertion and exiting slightly posterior to the anterior tibial spine. This is overdrilled with a cannulated 3/8 in. drill bit.

Graft Passage and Tensioning

- With the knee flexed at 90°, a curved Kelly is passed through the intercondylar notch and posterolateral capsule into the over-the-top space where the graft was passed through the notch posteriorly and then through the tibial tunnel from posterior to anterior (Fig. 26.8).
- The graft is tensioned at 70° of flexion with the tibia in external rotation and with a posteriorly directed force. It is then sutured to the femoral origin of the LCL. After emerging from the tibial tunnel, the distal end of the graft is passed deep to the patellar tendon and sutured beyond Gerdy's tubercle onto itself (Figs. 26.9 and 26.10).

Closure

- A drain is placed posterolaterally and the knee lavaged with saline after which a 2-layer close takes place.
- Sterile gauze dressing and Jones bandage are applied.
- A hinged knee brace is applied and locked at 70° of flexion with the tibia in external rotation to decrease tension on the lateral side.

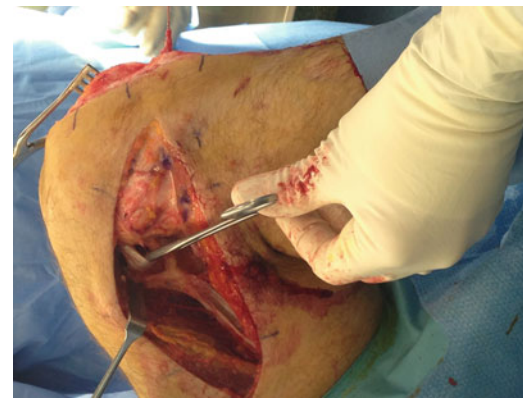


Fig. 26.8 Graft is passed from over-the-top passage through to the notch

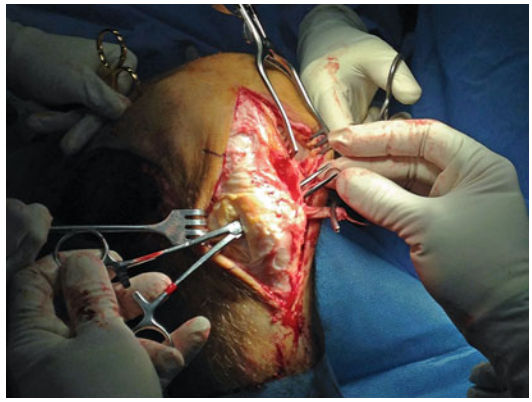


Fig. 26.9 Plane developed for iliotibial band graft to traverse deep to the patellar tendon

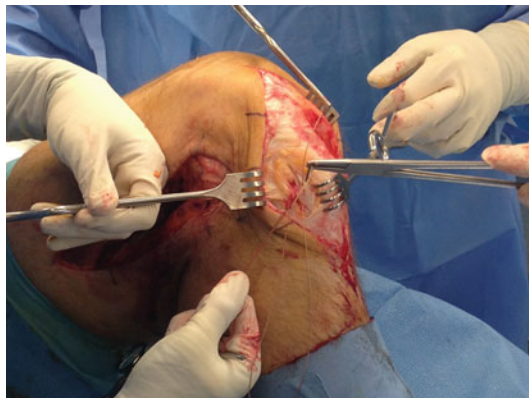


Fig. 26.10 Secure reconstruction back onto its insertion at Gerdy's tubercle

26.3 Discussion

The MacIntosh procedure has gone through several iterations over decades and, in turn, has found itself on the forefront of the discussion around rotational instability of the knee. Its application and efficacy as an adjunct to the intra-articular ACL reconstruction are being studied at length.

Researchers from Italy studied the pivot shift phenomenon in vivo to determine the effect of intra-articular and extra-articular ACL reconstruction. They measured both the maximum anterior tibial translation (ATT) and the axial tibial rotation (ATR). Results highlight that extra-articular reconstruction had minimal effect compared to intra-articular reconstruction in reducing anterior translation of the tibia, whereas tibial rotatory instability was significantly decreased by the use of lateral tenodesis as previously reported [12].

Early results from Ireland and Trickey suggested that after a 2-year follow-up, there was significant improvement in clinical and functional stability after an extra-articular MacIntosh procedure. Seventy-four percent of patients had returned to some form of sporting activity, while 84 % of patients presented with a negative pivot shift test [7]. Furthermore, Dempsey and Tregonning reviewed 25 patients with combined extra- and intra-articular MacIntosh ACL reconstructions or the MacIntosh II as well as 22 patients with isolated extra-articular ACL reconstructions or the MacIntosh I. After 9 years, there were no subjective symptoms of instability with 62 % of knees having good to excellent Lysholm scores and 83 % remaining active in sport. They also found that the addition of the intra-articular component made no significant difference in subjective outcome or long-term function [2].

Decades later, Johnston et al. reported on a retrospective cohort of 84 knees who had undergone the MacIntosh LSOT procedure whose results were similar to the previously published literature (i.e., 61 % of patients with good to excellent Lysholm scores, negative pivot shift in 88 % of knees). They concluded that the LSOT could be a viable substitute for arthroscopically assisted ACL reconstruction for those whose scar cosmesis is not a priority [8].

Most recently, there have been several studies investigating the use of the extra-articular MacIntosh procedure in combination with a more modern intra-articular ACL reconstruction technique using hamstring as a method to reduce rotational instability seen with the latter. Vadala et al. found no significant difference in KT-1000 measurements and Lachman testing between patients who had the combined procedure versus the MacIntosh in isolation. There was, however, a significant residual pivot shift in the group who did not have the extra-articular reconstruction [15]. This supports the concept that the MacIntosh procedure may significantly reduce rotational laxity of the knee following ACL injury. Sonnery-Cottet et al. has reported preliminary data on outcomes of this combined ACL reconstruction and anterolateral ligament reconstruction, which is described as

the MacIntosh I. Their indications to apply this combined method include the presence of a Segond fracture, chronic ACL lesion, grade 3 pivot shift, high level of sport participation and pivoting sports, and a radiographic lateral femoral notch sign. After an average follow-up of 2 years, the Lysholm, Tegner, objective and subjective IKDC scores, as well as the pivot shift exam had improved although 10% of knees in their study had persistent pivot shift postoperatively [14]. Long-term results are not yet available, and the effect on posttraumatic OA is also not yet known.

Conclusions

Just as a pendulum returns to its equilibrium once displaced, the original application and theory behind the MacIntosh procedure have swung back into the forefront of orthopedic surgery. Interest in comparing biomechanical and clinical outcomes of ACL reconstruction with or without the augmentation using a lateral extra-articular tenodesis has continued to grow with promising preliminary results. One international, multicenter, randomized control trial is currently underway comparing isolated anatomic ACL reconstruction with an identical procedure augmented with a Macintosh II construct. This study will undoubtedly provide further information on graft failure, function, strength, range of motion, and quality of life when utilizing an extra-articular augment [5].

With recent anatomic advances in the definition and function of the anterolateral ligament of the knee, the Macintosh procedure has regained popularity. The optimal indication for an extra-articular augmentation with primary ACL reconstruction is as yet unknown; however it is likely to be most useful in patients with a chronic Segond-type lesion (i.e., lateral capsular injury, bony, or otherwise) and patients with generalized ligamentous laxity or in revision situations with excess rotational laxity. In the pediatric population it provides an option to impart some stability with less risk of physeal injury. Further research will help to clarify its specific role in primary ACL injury and the longer-term consequences on return to function and the development of arthritis post reconstruction.

Fact Box

- Pivot shift test mimics axial tibial rotatory instability.
- Lateral tenodesis or the MacIntosh procedure has been shown to effectively reduce the pivot shift phenomenon.
- The MacIntosh procedure as an augment or revision to intra-articular ACL reconstruction may effectively address both pivot shifting and anterior translation in patients who experience symptoms of both.
- The extra-articular portion of the original MacIntosh I likely mimics the function of the anterolateral ligament (ALL) and is similar to ALL reconstruction techniques currently described with minor modifications.

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