

An Illustrated History of Anterior Cruciate Ligament Surgery

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INTRODUCTION

Reconstruction of a ruptured anterior cruciate ligament (ACL) is one of the most common procedures performed by sports medicine surgeons today. Few would dispute the importance of the ACL to knee stability and function. Given the success of present surgical techniques, most surgeons would recommend an anatomic intra-articular reconstruction for their high-demand patients or those with function disability due to acute or chronic ACL deficiency. Excellent surgical results can be expected in most of these patients. However, it has taken over a century of work to achieve this level of proficiency and consistently good patient outcomes.

As our recognition of the importance of the ACL developed, various techniques were described to address the problem of ACL rupture. Early attempts focused on primary repair, with unsatisfactory results. Surgeons then became interested in substituting the ACL with extra-articular reconstructions using local structures. Over time, the importance of a more anatomic intra-articular reconstruction became apparent. Tissue grafts and prosthetic replacements were investigated. With the advancement of arthroscopic capabilities, intra-articular reconstructions with soft-tissue grafts became the standard and remain so to this day. Despite the predictably good results, refinements to this basic strategy continue to evolve.

The ACL remains the most frequently studied ligament in orthopedic research. Hundreds of papers are sub-

mitted each year on topics related to the ACL. Much of the focus has shifted to graft selection and fixation options, outcomes, rehabilitation, and injury prevention. However, debate still exists regarding optimal graft positioning and orientation and the need for even more anatomic reconstructions such as the double-bundle ACL reconstruction. To better understand the context in which these debates exist, we look back on the many successes and failures of the surgical techniques espoused over the past century.^{6,67} Understanding the evolution of these techniques may help guide our thinking when evaluating novel ACL reconstruction strategies.

PRIMARY REPAIRS

The earliest surgical attempts to address ACL deficiency focused on primary repair of the torn ligament. In 1900, Battle⁴ described a successful outcome of one case at 2 years following repair. This concept was furthered by the report of a successful repair with 8-year follow-up published by Mayo Robson in 1903.⁵² Hey Groves^{29,30} disagreed with the concept of primary repair, noting that the ruptured ligament often is torn or destroyed that "direct suture would have been utterly impossible." Instead, he recommended reconstruction with a fascia lata graft. In the United States, the major advocates of repair or reconstruction if necessary were Campbell in the 1930s and O'Donoghue in the 1950s.^{10,11,59,60}

Despite the work of these early pioneers, from the 1930s through the 1960s the debate was less over primary repair versus reconstruction than it was over whether any procedure at all need be done. Prominent surgeons such as Hughston³³ and Quigley⁶³ stated that the ACL did not need repair if the associated meniscal and capsular pathology was appropriately addressed. They failed to recognize the importance of the ACL as the primary restraint to anterior translation of the tibia and the prevalence of isolated ACL rupture.

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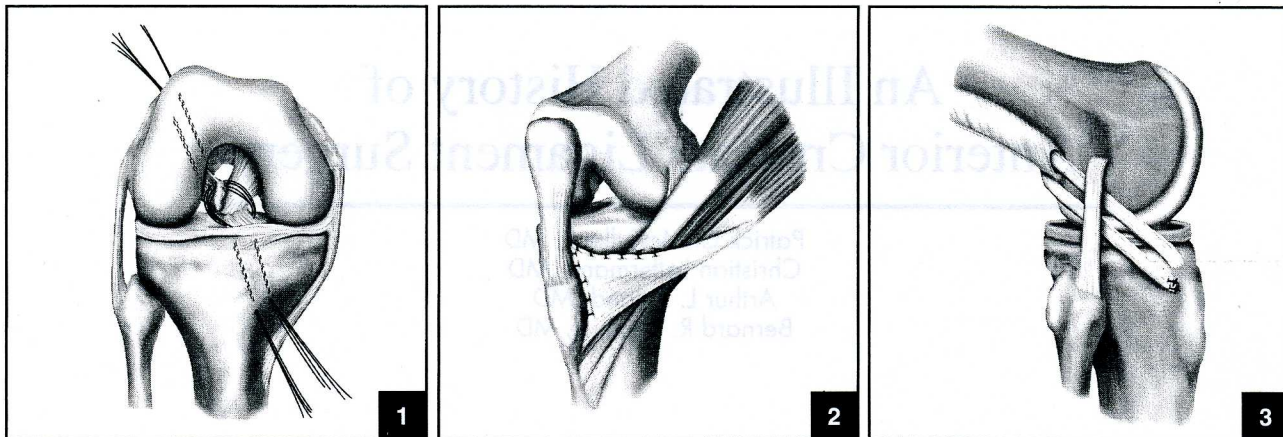


Figure 1. Marshall procedure. Primary repair using over-the-top suture fixation. **Figure 2.** Slocum pesplasty. Pes transfer to a position where it functions primarily as an internal rotator rather than a flexor. Posteromedial capsular reefing and medial collateral ligament advancement were added to limit posteromedial rotatory instability. **Figure 3.** MacIntosh 1. Lateral extra-articular reconstruction with a strip of iliotibial band passed through the intermuscular septum and under the lateral collateral.

Renewed interest in primary repair came in the early 1970s. In 1972, Feagin¹⁸ presented his initial success with repair in West Point cadets during the annual American Academy of Orthopaedic Surgeons meeting. This idea was supported by MacIntosh⁴⁸ who described good results with suture repair of the ligament behind the lateral condyle—the so-called “over-the-top” repair. This repair was later modified by Marshall and quickly became the preferred surgical treatment (Figure 1).⁵¹

However, interest in primary repair did not last long. Marshall abandoned primary repair alone in favor of a fascia lata augmented reconstruction.⁵⁰ The final blow came in 1976 when Feagin presented his 5-year follow-up on the West Point cadets. Despite initial success, his patients had developed recurrent instability and progressive deterioration of function.¹⁹

EXTRA-ARTICULAR RECONSTRUCTIONS

By 1970, it became clear that ACL deficiency led to functional disability and that some type of reconstruction was necessary to address this problem. Surgeons began to scientifically address the problem through ligament cutting studies^{23,41} and mechanical testing.^{40,57} This led to the concept of “rotational instability of the knee” described by Slocum and Larson.⁶⁶ They noted that a valgus and external rotation injury would result in disruption of the medial collateral ligament (MCL), posterior medial capsule, and ACL. However, they failed to recognize the importance of isolated ACL injury. Instead, surgical strategies were focused not on the ACL itself, but rather on treating the resultant anterior medial rotatory instability.⁶⁵ Several procedures were described to prevent subluxation of the tibia and hold it in a reduced and internally rotated position, including pes anserinus transfer, posterior medial

capsular reefing, and advancement of the MCL to a more proximal and posterior position (Figure 2).⁶⁵ In 1973, Nicholas published his “five-in-one” technique. This was similar to Slocum’s reconstruction with the addition of a medial meniscectomy and vastus medialis oblique advancement.⁵⁶ This procedure was popular in the mid-1970s. Patients were then routinely casted for 6 weeks in a flexed and internally rotated position, which often led to significant motion loss. Although these procedures decreased rotational translation, they failed to address the clinical problem of anterior instability.^{57,62}

In 1971, Kennedy and Fowler⁴⁰ published an anatomic study that showed the ACL could be injured without involvement of the medial capsular structures. The following year, the “pivot shift phenomenon” was published by Galway et al.²² Hughston incorporated these findings into his rotational instability theory calling it “anterior lateral rotatory instability.” He attributed this finding primarily to lateral capsular injury, which could be accentuated by ACL deficiency.³² The emphasis then shifted to laterally based procedures designed to limit anterior subluxation of the tibia on the lateral side. MacIntosh described an extra-articular reconstruction using a strip of the iliotibial (IT) band, which would later be referred to as the MacIntosh 1 (Figure 3). Other procedures using the IT band were simultaneously described by Losee et al,⁴⁶ Ellison,¹⁶ and Andrews and Sanders.² Losee et al⁴⁶ described passing the IT band through an extra-articular tunnel, through the lateral gastrocnemius, and then passing under the lateral collateral ligament (Figure 4). Both of these reconstructions involved detaching the IT band proximally. Ellison¹⁶ described a “dynamic” reconstruction also using the IT band detached distally instead of proximally. He routed this graft under the lateral collateral and fixed it distally. It was thought that the pull of the

