Knee Ligament Injuries

Extraarticular Surgical Techniques

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Preface

Extra-articular reconstruction has been employed over the past century to address anterior cruciate ligament (ACL) deficiency, but the technique has not gained favor owing primarily to residual instability and secondarily to the development of degenerative changes in the lateral and medial compartments of the knee. As a consequence, intra-articular arthroscopic reconstruction has become the technique of choice. However, we know from several clinical and biomechanical studies that intra-articular reconstruction, despite the introduction of so-called anatomical reconstruction, does not completely restore normal knee kinematics. Therefore some authors have recommended extra-articular reconstruction in conjunction with an intra-articular technique.

This book provides in-depth descriptions of the extra-articular surgical techniques that may be employed when performing ligament reconstruction in patients with injuries involving the posterolateral and posteromedial corners of the knee. It is intended as a practical, "how to" manual that will be of value for both the trainee and the more experienced surgeon. Many of the techniques relate to the central pivot of the knee, i.e., the anterior and posterior cruciate ligaments. For each technique, indications, presurgical planning, postsurgical follow-up, and complications are discussed in addition to the surgical details. Numerous tips and pearls are provided and the techniques are clearly depicted in informative high-quality illustrations.

Rome, Italy — Fabrizio Margheritini
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First of all, we thank the Magellan Society, an International Society that brings together as members the Traveling Fellows and the guiding Godparents of different Sports Medicine societies across the world. Among the members of this society we found the contributors to this book, who we thank for sharing their expertise and for presenting what we believe to be the most complete and up-to-date guidance on the diagnosis and treatment of peripheral instability. The value of this book lies only in the knowledge of these authors.

Then we would like to thank our families for allowing us to spend time over this project without feeling too much guilt.

We also wish to thank the staff at Springer for overseeing the entire publication process until the release of the book.

Finally, we would like to thank Dr. John A. Feagin and Dr. Werner Muller, whose work inspired the idea of writing this book.

Contents

What Is New in Knee Surgery?

1

Matthew J. Boyle and Dean C. Taylor

As is often said, what was once old is now new again. In recent years, the traditional orthopedic principle of restoration of anatomy has experienced a renaissance within the field of extra-articular knee reconstruction. Knee surgeons have moved again toward more anatomic restoration, while continuing to develop extra-articular augmentation procedures to protect these anatomic reconstructions.

For anterior cruciate ligament (ACL) injuries, extra-articular knee reconstruction initially became popular in the late 1960s, when the focus of treating patients with ACL injury began to move from anatomic primary repair to extra-articular reconstructions using local structures. Early techniques such as the Slocum and Larson [1], Losee et al. [2], Ellison [3], and Andrews and Sanders [4] procedures were developed in an attempt to control rotational instability of the knee utilizing extra-articular biomechanics. With advancing anatomic and biomechanical understanding and with technological development, the treatment of ACL injury has now evolved into an anatomic intra-articular reconstruction; however, these early extra-articular techniques remain useful as conjunct procedures in the dramatically unstable or revision reconstructive knee [5].

As has been the case for ACL injuries, there also has been a renewed emphasis on anatomic reconstruction procedures for other knee ligament injuries. Interesting recent developments in the field of extra-articular knee reconstruction include advances in the anatomic management of patellofemoral instability, posterolateral corner injury, medial collateral ligament injury, and pediatric ACL injury and in the understanding of allograft and platelet-rich plasma use.

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1.1 Patellofemoral Instability

Medial patellofemoral ligament (MPFL) reconstruction has become a popular surgical option in the management of patellofemoral instability in select patients. Recently, Fulkerson and Edgar have suggested that the MPFL reconstruction may be anatomically incorrect [6]. Through detailed anatomic dissections of the deep medial knee retinaculum, Fulkerson and Edgar have demonstrated a consistent prominent structure extending from the distal deep quadriceps tendon to the adductor tubercle region, forming a distinct medial quadriceps tendon-femoral ligament (MQTFL). In their published series, reconstruction of this anatomic structure yielded consistent medial stabilization of the patellofemoral joint without drilling into the patella in 17 patients with recurrent patella instability with greater than 12 months follow-up [6]. Further research is required to investigate the anatomic and functional importance of the MQTFL.

1.2 Posterolateral Corner Injury

Although posterolateral corner (PLC) injuries may occur in conjunction with up to 7.5 % of ACL injuries [7], this combined injury pattern is still often missed. Failure of recognition and appropriate treatment of PLC injury places increased stress on ACL reconstructions and may predispose patients to early graft failure. Anatomic extra-articular restoration of injured PLC structures will likely protect anatomic ACL reconstruction and optimize functional outcome in patients presenting with this combined injury. Kim et al. recently demonstrated that within a population of 425 patients, 32 patients who presented with combined PLC and ACL injury and were managed with anatomic PLC and ACL reconstruction had significantly less anterior tibial translation and comparable functional outcome scores at 2 years postoperatively when compared to 393 patients with isolated ACL injury who were managed with ACL reconstruction alone [7]. Interestingly, in a recent cohort study, Yoon et al. found no objective or functional benefit to the addition of a popliteal tendon reconstruction in addition to an anatomic PLC reconstruction [8]. This illustrates the importance that knee surgeons remain focused on restoration of anatomy in order to achieve the best possible patient outcomes.

1.3 Medial Collateral Ligament Injury

Early medial collateral ligament (MCL) reconstruction involved nonanatomic sling-type procedures that frequently resulted in residual laxity, loss of knee motion, and disappointing patient outcomes. Over the past 10 years, a number of more anatomic procedures for MCL reconstruction have been developed, typically involving hamstring tendon graft with modern fixation devices to reconstruct the superficial MCL. These procedures have demonstrated improved results compared to early techniques; however, they fail to address the injured posteromedial structures in addition to the superficial MCL. Recently, LaPrade and Wijdicks, in conjunction with the University of Oslo, Norway, have undertaken detailed quantitative anatomic studies in addition to static and dynamic biomechanical studies in order to develop an anatomic medial knee reconstruction. LaPrade and Wijdicks' [9] technique consists of a reconstruction of the proximal and distal divisions of the superficial medial collateral ligament in addition to the posterior oblique ligament (POL) using two separate grafts. In a group of 28 patients with MCL insufficiency followed prospectively for an average of 18 months, LaPrade and Wijdicks found this anatomic technique to restore valgus, external rotation, and internal rotation stability and improve patient function [9]. Future medial knee reconstructions may benefit from the addition of POL reconstruction in order to truly restore patient anatomy and optimize postoperative function.

1.4 Pediatric Anterior Cruciate Ligament Injury

The optimal surgical technique in pediatric ACL reconstruction remains a source of much debate. Although recent literature suggests that transphyseal ACL reconstruction in Tanner stage 1 and 2 children can achieve satisfactory outcomes with low complication rates [10], the concern of growth disturbance continues to stimulate interest in potentially nonanatomic and extra-articular procedures in these young patients. Kennedy et al. recently undertook a biomechanical cadaveric study investigating three ACL reconstruction techniques that attempt to avoid disruption of the physis: the all-epiphyseal technique, the transtibial over-the-top technique, and the iliotibial band physeal-sparing technique [11]. All techniques restored some stability to the knee. The iliotibial band reconstruction best restored anteroposterior stability and rotational control, although it appeared to overconstrain the knee to rotational forces at some flexion angles.

1.5 Allograft Tissue

The use of allograft tissue in ligamentous knee reconstruction remains a topic of debate. The orthopedic community's understanding of allograft biomechanical properties continues to evolve. Allograft remains an excellent option in patients undergoing multiple ligament reconstruction in order to increase graft number, reduce donor site morbidity, and limit operative duration. Isolated MCL reconstruction also provides a suitable facet for allograft due to concern for donor site morbidity. Marx and Hetsroni recently published a technique to reconstruct the MCL using Achilles tendon allograft with encouraging results [12]. Despite these promising indications, the benefit of allograft reconstruction of isolated ACL injuries remains unclear. Spindler et al., in a study of 378 patients undergoing ACL reconstruction, recently demonstrated allograft use to be a significant predictor of poorer International Knee Documentation Committee and Knee Injury and Osteoarthritis Outcome Score outcomes at 6 years postoperatively [13].

1.6 Platelet-Rich Plasma

Platelet-rich plasma (PRP) therapy has been introduced to orthopedic surgery with the aim of enhancing tissue healing by increasing the concentration of growth factors and thereby moderating the inflammatory response, increasing cell migration, and stimulating angiogenesis. While basic science and laboratory studies have suggested that PRP therapy shows promise in a number of orthopedic subspecialties, the clinical significance of this therapy remains unclear. The majority of PRP research in knee ligamentous surgery has focused on ACL reconstruction. Although the basic science results have been encouraging, there unfortunately have only been two recent randomized trials investigating the effect of PRP on clinical outcomes. Mirzatolooei et al., in a randomized controlled trial of 50 patients undergoing ACL reconstruction using hamstring autograft, demonstrated no significant difference in clinical outcomes of bone tunnel widening between patients who had PRP introduced into tibial and femoral bone tunnels perioperatively and patients who did not [14]. Cervellin et al., in a randomized controlled trial of 40 patients undergoing ACL reconstruction with bone-patellar tendon-bone autograft, identified a small improvement in Victorian Institute Sport Assessment scale but no difference in visual analog pain scale or donor site bony healing in patients who had PRP gel applied to patellar and tibial bone harvest sites compared to patients who did not receive PRP gel [15]. Clinical studies have yet to convincingly support the use of platelet-rich plasma in knee ligamentous reconstruction.

Conclusion

Extra-articular knee reconstruction has evolved to a state where surgeons have seen improved results when advances in biological and anatomic understanding are applied to surgical techniques. This chapter has outlined many of the recent advances that have improved knee surgery outcomes.

The Magellan Orthopaedic Society has contributed significantly to the advancement of knee surgery through international collaboration of some of the world's most exceptional orthopedic sports medicine specialists. The talented Magellan members' chapters in this book will dive deeply into the internationally derived knowledge and provide thoughtful and creative solutions to challenging knee injuries.

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Anatomy and Biomechanics

2

Sven Scheffler

The peripheral compartments of the human knee joint can be divided into an anterior, posterior, medial, and lateral compartment.

The anterior compartment consists of the patellar tendon and Hoffa fat pad. Its main function is the force transduction of the upper leg via the extensor apparatus of the knee joint, i.e., the quadriceps tendon, to the lower leg via the patellar tendon. The posterior compartment mainly consists of the posterior capsule. The popliteus muscle runs posteriorly below the posterior capsule and inserts to the tibia above the soleus muscle. The tendons of the medial and lateral heads of the gastrocnemius muscle cross from distal to proximal the posterior periphery of the knee joint to attach to the distal femur and the lateral femoral condyle.

More important for overall knee function and often the location of soft tissue injuries are the medial and lateral periphery, which will be described in two separate sections.

2.1 Medial Periphery

2.1.1 Anatomy

The medial periphery of the human knee joint has been described to consist of three soft tissue layers [37]. The most superficial layer I is found subcutaneously and is formed by parts of the deep crural fascia. From proximal to distal it covers the sartorius and quadriceps muscle, blends anteriorly with the retinaculum, forming the deep crural fascia posteriorly, and runs distally toward the pes anserinus and tibial periosteum [41] (Fig. 2.1a).

Layer II is formed by the largest structure at the medial aspect of the knee, the superficial medial collateral ligament (sMCL) (Fig. 2.1b). It has been described to

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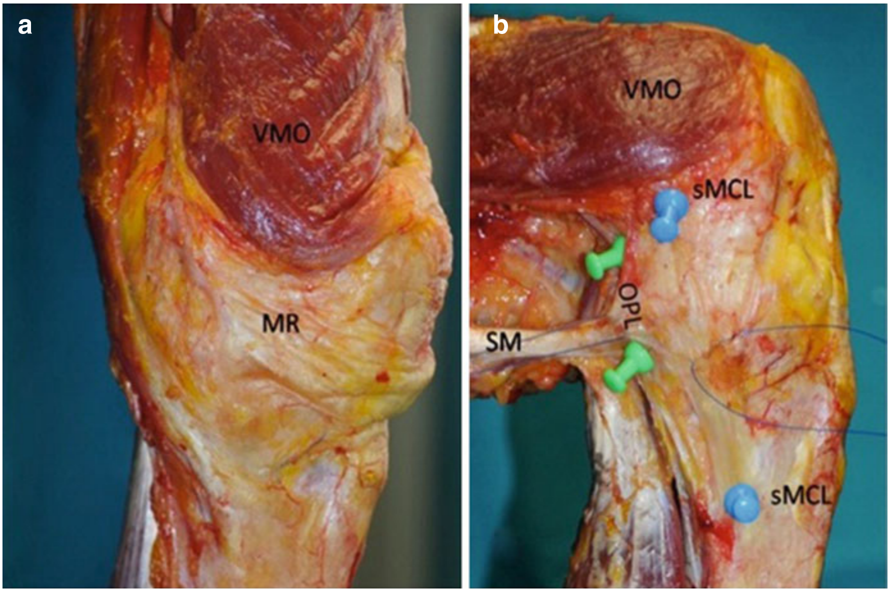

Fig. 2.1 (**a**, **b**) Superficial medial collateral ligament and posterior oblique ligament, *sMCL*: superficial medial collateral ligament; *MR*: medial retinaculum; *OPL*: oblique posterior ligament; *SM*: semimembranosus tendon; *VMO*: vastus medialis obliquus muscle

be between 10 and 12 cm long [23, 37]. It originates at the posterior-superior edge of the medial femoral epicondyle [20] and fans out to the tibial crest at 5–7 cm below the joint line, where two separate attachments can be found. The proximal tibial attachment is primarily to the anterior arm of the semimembranosus tendon. The larger distal bony attachment can be found anteriorly to the posteromedial crest of the tibia. Posterior to its tibial attachment, the sMCL blends within tibial expansions of the semimembranosus tendon. Anterior to the femoral attachment of the sMCL, it is continuous with the medial patellofemoral ligament (MPFL). The MPFL lies anterior to the medial capsule extra-articularly. It has been reported to have a length of approximately 55 mm and a varying width of 3–30 mm [1]. At the proximal edge of the MPFL, the vastus medialis obliquus muscle attaches. Often the MPFL can only be identified as a thickening of a fascial layer running from the proximal-medial edge of the patella to its femoral attachment between the posterior-superior site of the medial epicondyle and anterior-inferior site of the adductor tubercle [2, 20]. Soft tissue connections can be found to femoral attachments of the adductor magnus tendon and sMCL. Three muscles insert with their tendons to the posteromedial side of the knee joint. Most proximally, the adductor magnus tendon is attached in an osseous depression posterior-proximal to the adductor tubercle. At the distal-medial aspect of the adductor magnus tendon, a thick fascial expansion adheres to the medial gastrocnemius tendon, the capsular arm of the posterior oblique ligament, and the posteromedial capsule. More distally, the medial gastrocnemius tendon attaches in a depression proximal-posterior to the gastrocnemius tubercle. It has a thick fascial attachment to the adductor magnus tendon and a thin fascial attachment along its medial and posterior aspect to the capsular arm of the POL. Most distally, the semimembranosus tendon attachments are located on the medial and posteromedial parts of the tibia. The anterior arm of this distal insertion attaches deep to the proximal tibial attachment of the sMCL in an oval-shaped pattern distal to the tibial joint line. A direct arm connects to the posteromedial part of the tibia.

The medial joint capsule constitutes layer III. Posteriorly, its oblique fibers blend into layer II. It forms the deep MCL (dMCL) as a thickening below the sMCL, which spreads from the femoral condyle via the medial meniscus to the tibia. The dMCL shows a separate meniscotibial and meniscofemoral attachments, while blending with the sMCL posteriorly. The posteromedial capsule (PMC) is formed by dense tissue of layers II and III. Its femoral attachment site is at the adductor tubercle [12, 13, 24, 37]. Some authors identified a ligament-like structure within the PMC and termed it as the posterior oblique ligament (POL) [12, 13, 24]. The posterior border of the dMCL blends into the central arm of the POL, just posterior to the posterior edge of the sMCL. The POL is created by three fascial attachments to the semimembranosus tendon. It can be divided into a capsular, central, and superficial arm [12, 13]. The central and superficial arms blend into each other to form its femoral attachment posterior-inferior to the adductor tubercle and anterior-inferior to the gastrocnemius tubercle [20]. Distally, the thin superficial arm, which runs parallel to the posterior edge of the sMCL, merges with a distal expansion of the semimembranosus tendon. The strongest central part attaches distally to the posteromedial aspect of the medial meniscus, the posteromedial capsule, and the posteromedial aspect of the tibia [13, 20]. Anteriorly to the sMCL, layer III blends with layer I into the retinaculum.

The pes anserine tendons are situated between layers I and II–III and connect distally to the anteromedial aspect of the proximal part of the tibia. They consist of the sartorius, gracilis, and semitendinosus tendon in a proximal to distal fashion.

2.1.2 Biomechanics

The medial and posteromedial structures of the knee joint are loaded throughout the overall range of knee motion under valgus loads, internal and external rotation [6], as well as anterior and posterior drawer loads. There is a sharing response between the respective structures of the medial knee site, which act as primary and secondary restraint to various loads. The superficial medial collateral ligament (sMCL) has been identified as the primary restraint to valgus laxity of the knee [7, 17, 26] (Fig. 2.2). Griffith et al. [6] found that the sMCL does not function as one unit, but that its distal division was carrying larger loads than its proximal division, especially at flexion angles >20°, while the proximal sMCL was experiencing similar loads at all flexion angles. These differences in load transmission have been attributed to the different anatomy of the tibial attachments of the sMCL with the distal portion attaching directly to the tibia, therefore transmitting loads directly to the bone. In contrast, the