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Superficial Quadriceps Tendon Graft for ACL Reconstruction

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ABSTRACT

Anterior cruciate ligament reconstruction remains the standard treatment for symptomatic anterior cruciate ligament deficiency in active patients, and graft selection continues to influence postoperative stability, donor-site morbidity, and return-to-sport outcomes. This review summarized the anatomy and function of the anterior cruciate ligament, the epidemiology, diagnosis, and treatment principles of anterior cruciate ligament rupture, and the current role of superficial quadriceps tendon graft in reconstruction. The available literature showed that superficial quadriceps tendon graft provided a large cross-sectional area, predictable graft diameter, and favorable biomechanical properties with lower anterior knee pain and less donor-site morbidity than bone-patellar tendon-bone grafts. When compared with hamstring grafts, quadriceps-based grafts achieved similar or better stability while preserving hamstring strength. Compared with allografts, synthetic grafts, and xenografts, superficial quadriceps tendon autograft generally showed more reliable biologic incorporation and lower failure risk in young or high-demand patients. Overall, superficial quadriceps tendon graft appeared to be a strong and safe option for primary anterior cruciate ligament reconstruction, although further long-term studies and standardized harvesting techniques are still needed.

Keywords: anterior cruciate ligament, ACL reconstruction, superficial quadriceps tendon, quadriceps tendon graft, autograft

INTRODUCTION

Anterior cruciate ligament (ACL) is the primary stabilizer of the knee against anterior tibial translation and contributes substantially to rotational control during cutting, pivoting, and landing activities. ACL injury is one of the most frequent knee injuries in active populations and is associated with recurrent instability, secondary meniscal injury, and an increased risk of post-traumatic osteoarthritis when treatment is inadequate. [1,2]

For decades, graft selection has remained one of the most important technical decisions in ACL reconstruction. Bone-patellar tendon-bone (BPTB) and hamstring tendon (HT) autografts have been widely used because both provide satisfactory stability and functional outcomes, yet each has well-recognized disadvantages such as anterior knee pain with BPTB and hamstring weakness or slower tendon-to-bone healing with HT. [3]

Superficial quadriceps tendon (SQT) graft has emerged as an attractive alternative

because it offers a broad tendon footprint, adequate graft length and diameter, and relatively low donor-site morbidity. Recent biomechanical and clinical evidence suggests that quadriceps-based grafts may provide outcomes comparable to conventional grafts while reducing some donor-site complaints, although concerns about technical variability and short-term revision risk still persist. [4,5]

This review article discusses the anatomy and function of the ACL, the epidemiology and diagnosis of ACL rupture, the general principles of management, and the current evidence regarding the use of superficial quadriceps tendon graft for ACL reconstruction.

LITERATURE REVIEW

Anterior Cruciate Ligament

Anatomy and Function

ACL is an intra-articular but extrasynovial structure extending from the posteromedial aspect of the lateral femoral condyle to the anterior intercondylar area of the tibia. It is composed predominantly of type I collagen and contains two functional bundles, the anteromedial and posterolateral bundles, which tighten differently across the flexion-extension arc and together provide control of anterior tibial translation and rotational stability.[1]

Histologically, ACL contains proximal, midsubstance, and distal zones with different cellular and extracellular matrix characteristics. These structural differences help explain the unique mechanical behavior of the ligament and its limited healing capacity after complete rupture.[6]

Functionally, ACL serves as the primary restraint to anterior tibial translation and as a secondary restraint to internal rotation, external rotation, and varus-valgus stress. Loss of ACL integrity results in abnormal knee kinematics and creates a biologic environment that may accelerate meniscal and chondral injury. [1,6]

ACL Rupture

Definition, Epidemiology, and Risk Factors

ACL rupture is a partial or complete tear of the anterior cruciate ligament and commonly occurs during non-contact deceleration, cutting, pivoting, or landing maneuvers. The burden of ACL rupture is highest in young and physically active individuals, and female athletes have a substantially greater injury risk than males participating in similar sports. [6,8,9]

Important risk factors include female sex, high body mass index, a narrow intercondylar notch, smaller ACL size, generalized ligamentous laxity, poor neuromuscular control, and prior ACL injury. Repetitive microtrauma and suboptimal training mechanics may further contribute to ligament overload and recurrent injury. [6,9]

Diagnosis and Differential Diagnosis

Diagnosis is based on the injury mechanism, the presence of a pop sensation, rapid hemarthrosis, and physical examination findings such as a positive Lachman test, anterior drawer test, or pivot-shift test. Magnetic resonance imaging helps confirm loss of normal ligament continuity and identifies concomitant injuries involving the meniscus, cartilage, or collateral ligaments. [6,10]

The main differential diagnoses include meniscal injury, medial collateral ligament injury, and Segond fracture. These conditions may mimic ACL injury clinically, but the distribution of tenderness, mechanical symptoms, and imaging findings usually help distinguish them. [11,12,13]

Management Principles

Treatment may be conservative or operative depending on age, activity demand, instability symptoms, and associated injuries. Structured rehabilitation may be considered in selected low-demand or older patients, but reconstruction is generally favored in young active individuals who aim to return to pivoting sports or who have functional instability. [7,8,14]

Postoperative rehabilitation is essential regardless of graft choice and typically emphasizes early restoration of extension, progressive motion recovery, quadriceps strengthening, neuromuscular training, and staged return to sports-specific activities. [7,8]

Superficial Quadriceps Tendon Graft

Definition and Anatomic Rationale

SQT graft refers to the superficial portion of the quadriceps tendon harvested as an autograft for ACL reconstruction. Quadriceps tendon has a larger cross-sectional area than many conventional grafts and can provide a predictable graft diameter, which is advantageous because larger graft diameter has been associated with improved structural robustness. [4,15]

Harvesting only the superficial or partial-thickness layer may preserve more of the extensor mechanism while still obtaining sufficient tissue for an all-soft-tissue graft. Preoperative imaging studies have also shown that quadriceps tendon dimensions can be estimated reliably, which is useful when hamstring graft size is uncertain. [4,15]

Surgical Technique and Rehabilitation

Quadriceps tendon graft harvesting is commonly performed through a short midline or suprapatellar incision with careful preservation of surrounding extensor structures. The graft may be prepared with or without a bone block, and fixation can be achieved with interference screws or suspensory devices depending on surgeon preference and graft configuration. [4,16]

The key technical considerations are achieving adequate graft length and thickness, avoiding suprapatellar violation when possible, creating anatomic femoral and tibial tunnels, and securing the graft under appropriate tension. Rehabilitation follows the same general ACL reconstruction principles but should also monitor extensor mechanism recovery and quadriceps strength. [4,16]

Comparison with Other Graft Options

Compared with BPTB autograft, quadriceps-based grafts provide similar knee stability and patient-reported outcomes while generally producing less anterior knee pain, less kneeling discomfort, and lower donor-site morbidity. These features make SQT especially appealing in patients who wish to minimize extensor mechanism symptoms associated with BPTB harvesting. [4,5,19]

Compared with hamstring tendon grafts, quadriceps-based grafts show comparable functional results and may preserve hamstring strength better because the flexor mechanism is not sacrificed. Some comparative studies have also reported more favorable Lachman or pivot-shift findings with quadriceps-based grafts. [4,5,19]

Peroneus longus graft is another alternative that can provide acceptable stability and return-to-sport results, but it raises concerns about donor-site morbidity at the ankle and potential changes in ankle biomechanics. In contrast, SQT avoids ankle morbidity and remains centered on the knee extensor mechanism, where contemporary harvesting techniques have reduced complications. [17,18]

Allografts eliminate donor-site morbidity but generally undergo slower biologic incorporation and have demonstrated higher failure rates in young or high-demand patients. Therefore, SQT autograft is usually preferred for athletes and active individuals who need durable biologic healing and lower rerupture risk. [19,20]

Synthetic grafts such as LARS may provide strong initial fixation and faster early rehabilitation, but their long-term limitations include elongation, mechanical wear, synovitis, and inconsistent durability. Autologous SQT remains more biologically integrated and therefore more predictable for routine primary ACL reconstruction. [21,22]

Xenografts remain investigational for most ACL applications because they are affected by immunologic concerns, graft processing effects on collagen integrity, and inconsistent clinical outcomes. Although

newer porcine xenograft technologies have shown encouraging safety signals, the evidence still supports autologous SQT as the more reliable option for contemporary practice. [23,24,25]

CONCLUSION

ACL rupture is a common injury that compromises both anteroposterior and rotational knee stability and may lead to persistent symptoms, secondary intra-articular damage, and long-term degenerative change. Accurate diagnosis and individualized management are therefore essential. [6,7,8]

Based on the currently available evidence, superficial quadriceps tendon graft is a strong and safe option for ACL reconstruction. It combines a large graft diameter and favorable biomechanical profile with relatively low donor-site morbidity, reduced anterior knee pain, and outcomes that are comparable to or better than several conventional graft choices in selected patients. [4,5,15,16,19]

Even so, the technique still requires careful surgical execution and more long-term comparative studies. Future work should focus on standardizing harvesting and fixation methods and clarifying the long-term revision profile of quadriceps-based grafts in different patient populations. [5,16]

Declaration by Authors

Ethical Approval: Not applicable

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