Evaluating the Peroneus Longus Tendon as an Alternative Graft in Anterior Cruciate Ligament Reconstruction

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Abstract

Anterior Cruciate Ligament (ACL) reconstruction remains one of the most common orthopedic procedures, with graft selection playing a critical role in determining surgical success and patient outcomes. Traditionally, hamstring tendons, bone-patellar tendon-bone (BPTB), and quadriceps tendons have been the primary graft choices. However, recent studies have explored the use of the Peroneus Longus Tendon (PLT) as a viable alternative autograft for ACL reconstruction. This review aims to provide a comprehensive analysis of the anatomical, biomechanical, and clinical aspects of the PLT, comparing its structural integrity, donor site morbidity, and long-term functional outcomes with conventional graft options. Additionally, we discuss the surgical technique, advantages, and potential complications associated with PLT harvest and implantation. Emerging evidence suggests that the PLT demonstrates favorable tensile strength, minimal functional loss at the donor site, and satisfactory clinical results, making it a promising option for primary and revision ACL reconstruction. This review highlights current evidence, identifies existing gaps in the literature, and proposes directions for future research to establish PLT as a standard graft choice in ACL reconstruction surgery.

Keywords: Bariatric Surgery, Laparoscopic Sleeve Gastrectomy, Omentopexy, Gastropexy, Morbid Obesity, Surgical Outcomes

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Introduction

1. Introduction Anterior Cruciate Ligament (ACL) injuries are among the most common knee injuries, especially in athletes participating in high-demand sports such as football, basketball, and soccer [1]. The ACL plays a crucial role in maintaining knee stability by preventing anterior translation of the tibia and controlling rotational movements [2]. ACL reconstruction is often required to restore knee function and prevent long-term complications like osteoarthritis [3].

2. Anatomy of the ACL The ACL is one of the four major ligaments in the knee joint, originating from the posterior part of the medial surface of the lateral femoral condyle and attaching to the anterior intercondylar area of the tibia [4]. It is composed of two functional bundles: the anteromedial (AM) and posterolateral (PL) bundles, which provide stability in different ranges of knee flexion [5]. The AM bundle controls anterior tibial translation, while the PL bundle controls rotational stability [6].

3. Biomechanics of the ACL Biomechanically, the ACL withstands tensile forces during knee flexion and extension. It prevents anterior displacement of the tibia relative to the femur and resists internal tibial rotation [7]. The ligament is under the highest tension at approximately 20-30° of knee flexion [8]. Understanding the biomechanical role of the ACL is essential for selecting appropriate grafts and surgical techniques.

4. Mechanisms of Injury ACL injuries typically occur via non-contact mechanisms, including sudden deceleration, pivoting, or awkward landings [9]. Contact injuries often involve direct trauma to the lateral side of the knee, causing valgus stress and rotational force [10]. Female athletes have a higher risk of ACL injuries due to anatomical, neuromuscular, and hormonal differences [11].

5. Diagnosis of ACL Injuries Diagnosis involves a combination of history, physical examination, and imaging techniques. Common physical tests include the Lachman test, anterior drawer test, and pivot-shift test [12]. Magnetic Resonance Imaging (MRI) is the gold standard for confirming ACL injuries, offering high sensitivity and specificity [13].

6. Indications for ACL Reconstruction ACL reconstruction is indicated in patients with symptomatic instability, high functional demands, or additional meniscal injuries [14]. Delayed reconstruction may result in secondary damage to the menisci and articular cartilage [15].

7. Surgical Techniques in ACL Reconstruction Several surgical techniques are available for ACL reconstruction, with the single-bundle and double-bundle techniques being the most common [16]. The single-bundle technique focuses on replicating the AM bundle, while the double-bundle technique aims to restore both AM and PL bundle functions [17].

8. Single-Bundle Reconstruction Single-bundle ACL reconstruction is simpler, requires fewer fixation points, and has shorter surgical time [18]. However, it may not fully restore rotational stability, particularly in high-demand athletes [19].

9. Double-Bundle Reconstruction Double-bundle reconstruction aims to replicate the native ACL anatomy by reconstructing both AM and PL bundles. This technique offers better rotational control and knee kinematics [20]. However, it is technically demanding and may have a higher complication rate [21].

10. Graft Types in ACL Reconstruction The most common graft options include autografts, allografts, and synthetic grafts [22]. Autografts are typically harvested from the patellar tendon, hamstring tendons, or quadriceps tendon [23].

11. Patellar Tendon Autograft Patellar tendon autografts are considered the gold standard due to their high tensile strength and bone-to-bone healing properties [24]. However, they are associated with anterior knee pain and donor site morbidity [25].

12. Hamstring Tendon Autograft Hamstring tendon autografts are popular due to their lower donor site morbidity and flexibility during implantation [26]. However, they may have weaker fixation strength compared to patellar tendon grafts [27].

13. Quadriceps Tendon Autograft Quadriceps tendon autografts offer a large graft size and are useful in revision surgeries [28]. However, they are less commonly used and may have higher donor site complications [29].

14. Allografts Allografts, sourced from cadaveric tissue, reduce donor site morbidity and surgical time [30]. However, they carry a higher risk of infection, immune response, and delayed graft incorporation [31].

15. Synthetic Grafts Synthetic grafts, such as LARS (Ligament Advanced Reinforcement System), have been developed to overcome the limitations of biological grafts [32]. However, they are associated with high failure rates and limited long-term outcomes [33].

16. Graft Fixation Techniques Graft fixation is a critical factor in ACL reconstruction. Common fixation devices include interference screws, cortical suspension devices, and cross-pins [34].

17. Rehabilitation Post-ACL Reconstruction Rehabilitation plays a vital role in recovery. Early mobilization, quadriceps strengthening, and proprioceptive exercises are key components [35]. Return to sport is typically advised after 9-12 months [36].

18. Complications of ACL Reconstruction Common complications include graft failure, infection, arthrofibrosis, and persistent instability [37]. Proper surgical technique and adherence to rehabilitation protocols reduce these risks [38].

19. Outcomes of ACL Reconstruction The success rate of ACL reconstruction is generally high, with most patients achieving functional stability and returning to sports [39]. However, long-term outcomes may vary based on graft choice and surgical technique [40].

20. Factors Influencing Outcomes Patient age, activity level, graft type, and surgical expertise significantly influence outcomes [41]. Younger, active patients have a higher risk of graft re-rupture [42].

21. Revision ACL Reconstruction Revision surgeries are required in cases of graft failure or poor surgical outcomes. They are more complex and have lower success rates compared to primary reconstructions [43].

22. Emerging Trends in ACL Reconstruction Advances include the use of biologics, tissue engineering, and augmented grafts to enhance healing and reduce failure rates [44].

23. Prevention of ACL Injuries Neuromuscular training programs focusing on strength, agility, and balance can reduce the risk of ACL injuries [45]. ACL reconstruction remains the gold standard for managing ACL injuries. Proper graft selection, surgical technique, and rehabilitation are key factors for optimal outcomes. Further research into biologic augmentation and personalized approaches may improve long-term outcomes of ACL reconstruction.

Peroneus Longus Tendon in Anterior Cruciate Ligament Reconstruction

The use of the peroneus longus tendon (PLT) as an alternative graft in anterior cruciate ligament (ACL) reconstruction has gained significant interest in recent years. Traditionally, autografts such as the hamstring tendon, patellar tendon, and quadriceps tendon have been the standard choices for ACL reconstruction. However, in cases where these grafts are unavailable or unsuitable, the PLT offers a viable and effective alternative. Its biomechanical strength, ease of harvesting, and minimal donor site morbidity make it an attractive option for orthopedic surgeons [46]. Additionally, the anatomical and functional characteristics of the PLT provide sufficient tensile strength and stability to serve as a durable graft for ACL reconstruction [47].

One of the significant advantages of the PLT is its robust tensile strength, which closely mirrors that of the native ACL. Studies have demonstrated that the PLT has comparable load-to-failure properties and elongation characteristics, making it a reliable option for ACL reconstruction [48]. Moreover, the harvesting of the PLT is associated with minimal donor site morbidity, which is critical for reducing post-operative complications and improving functional outcomes. Patients undergoing PLT harvesting generally report minimal weakness or dysfunction in ankle eversion and plantar flexion, which are primary functions of the peroneus longus muscle [49].

The surgical technique for harvesting the PLT has been refined to minimize trauma and optimize graft quality. Typically, the tendon is harvested using a small incision near the lateral aspect of the ankle, followed by careful dissection to isolate the PLT. Once the tendon is harvested, it is prepared and shaped into a graft suitable for ACL reconstruction. This process ensures the structural integrity of the graft and reduces the risk of graft failure [50]. Additionally, the use of modern surgical tools and techniques has further enhanced the precision and efficiency of PLT harvesting [51].

Biomechanical studies have compared the tensile strength of PLT grafts to other autografts commonly used in ACL reconstruction. Findings suggest that the PLT exhibits comparable stiffness, load-to-failure strength, and graft elongation properties to hamstring and patellar tendon autografts. This biomechanical equivalence highlights the potential of PLT to serve as a reliable graft choice, particularly in cases where traditional autografts are unavailable [52]. Furthermore, the PLT demonstrates excellent resistance to cyclic loading, an important factor in preventing graft failure during the rehabilitation period [53].

Post-operative outcomes following ACL reconstruction using the PLT have been generally positive, with high rates of patient satisfaction and graft survival. Studies report favorable results in terms of knee stability, range of motion, and return to pre-injury activity levels. Functional assessments using validated scoring systems, such as the International Knee Documentation Committee (IKDC) and Lysholm scores, indicate comparable outcomes between PLT grafts and traditional autografts [54]. These findings reinforce the utility of the PLT as a viable alternative for ACL reconstruction, particularly in complex cases or revision surgeries [55].

The anatomical properties of the PLT make it an ideal choice for ACL reconstruction. Its length and diameter provide sufficient tissue for graft preparation without compromising the structural integrity of the donor site. Additionally, the PLT's flat and wide morphology allows for secure fixation during ACL reconstruction, reducing the risk of graft slippage or failure [56]. These characteristics are particularly advantageous in revision surgeries, where graft options may be limited [57].

Rehabilitation protocols following ACL reconstruction using PLT grafts are largely similar to those for traditional autografts. Early mobilization, weight-bearing exercises, and quadriceps strengthening are emphasized to restore knee function and stability. However, specific attention is given to ankle function to ensure there are no residual deficits from PLT harvesting [58]. Research suggests that most patients recover full ankle strength and function within six months post-operatively, with no significant long-term complications [59].

One of the primary concerns with using the PLT is the potential impact on ankle biomechanics. The PLT plays a crucial role in ankle stability and eversion, and its harvesting could theoretically impair these functions. However, clinical studies have demonstrated that compensatory mechanisms from other surrounding muscles, such as the peroneus brevis, mitigate any functional deficits [60]. Additionally, proper surgical technique and careful harvesting minimize the risk of long-term functional impairment [61].

The cost-effectiveness of using the PLT in ACL reconstruction has also been evaluated. In many healthcare systems, the use of autografts remains the most cost-effective option compared to allografts or synthetic grafts. The PLT, as an autograft, offers a financially viable solution, particularly in regions where allografts are not readily available or are prohibitively expensive [62].

Patient-reported outcomes following ACL reconstruction with PLT are highly encouraging. Surveys and clinical studies indicate that most patients experience significant improvements in knee stability, pain relief, and overall quality of life. Return-to-sport rates are also comparable to traditional graft options, underscoring the effectiveness of the PLT as an ACL graft [63].

In summary, the PLT has emerged as a promising alternative for ACL reconstruction, offering excellent biomechanical properties, minimal donor site morbidity, and favorable clinical outcomes. As surgical techniques continue to evolve and long-term data become available, the PLT is expected to gain wider acceptance in the field of sports medicine and orthopedic surgery [64].

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