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Peroneus Longus and Posterior Tibialis Bio-Implants in Knee Reconstruction

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Use of Peroneus Longus and Posterior Tibialis Bio-Implants in Knee Reconstruction

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Abstract

Human tendon allografts are widely used in reconstructive surgery. In particular, the use of both bone-patellar tendon-bone (BTB) and anterior tibialis tendon in knee reconstruction, including that of the Anterior Cruciate Ligament (ACL), is widely practiced. Although less commonly used at present, peroneus longus and posterior tibialis tendons are also used in these and other surgeries. Here, the biomechanical properties and clinical use of these tendons in procedures, including ACL reconstruction, is reviewed. Positive clinical experience has been gained and biomechanical studies also indicate that these tendons have the requisite strength for successful clinical outcomes. In summary, either peroneus longus or posterior tibialis may be considered as suitable tendons for sports medicine applications.

Introduction

Human tendon allografts have been used for clinical sports medicine applications for over two decades. In particular, reconstruction of the anterior cruciate ligament (ACL) is one of the most common soft tissue reconstructive procedures in orthopedic practice.[1,2] Allografts originally found their greatest acceptance in revision surgeries when autogenic grafts were no longer available or difficult to obtain. However, after favorable results with allografts were noted, these tendons became increasingly popular for primary reconstructions, as well.[2,3] Human allograft tissue offers several distinct advantages over autografts including shorter operative times, reduced surgical morbidity, decreased postoperative pain, and improved cosmesis. Also, recent advances in terminal sterilization technologies virtually eliminate the risk of disease transmission while maintaining clinically relevant properties. Allografts for sports medicine applications are recovered from a variety of sites and include the patellar tendon, semitendinosus tendon, tibialis tendon (both anterior and posterior), gracilis tendon, peroneus longus, and Achilles tendon.

Historically, the use of bone-tendon-bone (BTB) allografts gained widespread acceptance.[4,5,6] However, as increasing usage taxed supplies of donated tissues, alternative grafts were introduced and the use of anterior tibialis tendons became common for ACL, PCL, MCL, and posterolateral corner procedures.[4,7,8] In further advantage, the tibialis tendon also was not limited by the anatomical feature of the distance from bone-to-bone interface, exhibited in the BTB.

Now, there is a growing demand for additional grafts such as the posterior tibialis tendon and peroneus longus. For perspective, at one tissue bank, LifeNet Health, these grafts have been available for a number of years, and, in addition to 14,000 anterior tibialis tendons, over 10,000 *posterior tibialis* and 1,000 *peroneus longus* grafts have been distributed from 2006-2009 alone. Here, we describe studies that compare posterior tibialis and peroneus longus tendons to traditional grafts used for sports medicine reconstructive procedures.

Figure 1. Stress on ACL in Normal Activities

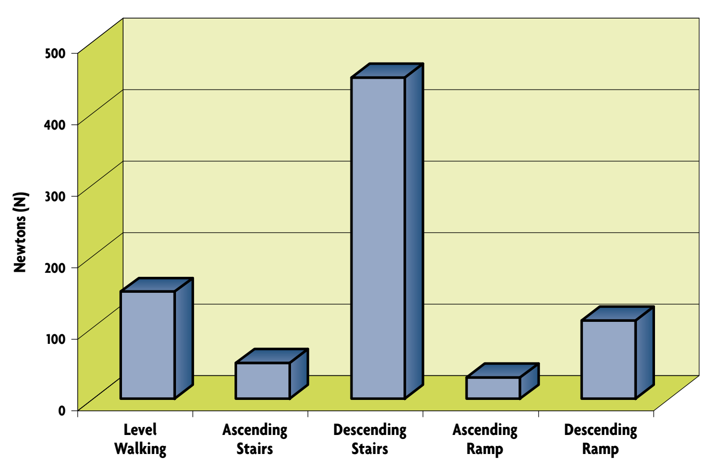


Table 1. Ultimate Tensile Strength of Native ACL in Various Study Groups	
Reference	Ultimate Tensile Strength (N)
Noyes and Grood[13]	734±266 to 1730±660
Woo, et al. [14]	658±129 to 2160±157
Rowden, et al. [15]	2195±427

Tendons for ACL Graft Reconstruction-Clinical Requirements

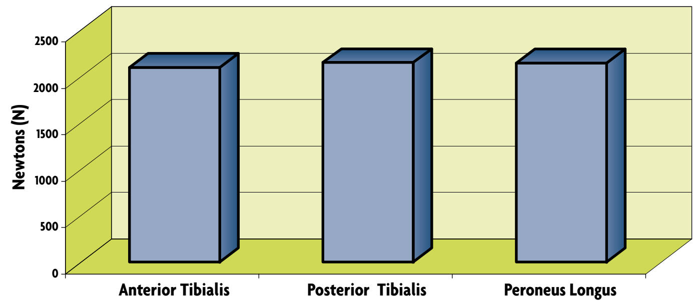
In assessing the requirements of soft tissue grafts used in ACL reconstruction, it is helpful to know the biomechanical requirements and properties of native ligaments. The strength required for normal activities was estimated by Noyes, et al.[9] to be 454 N based on the failure strength of the ACL. More detailed analyses were performed by Morrison[10-12] regarding the forces that the ACL and PCL (posterior cruciate ligament) are subjected to during activities of daily living. An overview of these data is shown in Figure 1.

By definition, a *functional* native anterior cruciate ligament would have the requisite strength to carry out these normal activities. The actual strength of isolated cadaveric tendons has been studied extensively. In representative studies presented here, the ultimate tensile strength of the native ACL, defined as the force tissue can tolerate before failure, is reported to range from 658 to 2195 N (Table 1). Note that the lowest ultimate load to failure was 658 N, representative of an extended age group up to 97, which was *well above the 454 N load required for 'daily living'* as reported in the previous paragraph. Thus, these values should be used as a guide for strength of an ACL substitute.

Peroneus Longus and Posterior Tibialis Tendon-Biomechanical Experience

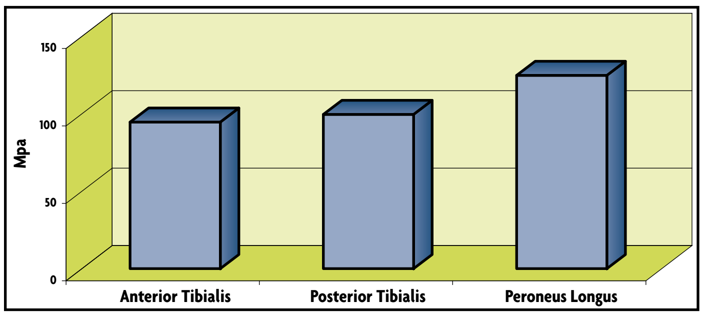
Chowaniec, et al.[16] examined the biomechanical properties of 15 anterior tibialis, 15 posterior tibialis, and 13 peroneus longus human allografts, all single stranded. As shown in Figure 2, these grafts exhibited near identical ultimate load to failure and were similar to the strongest native ACL values reported in Table 1. It is also worthwhile to note that these tendons are commonly used in double-stranded configurations.

Figure 2. Tendon ultimate tensile strength



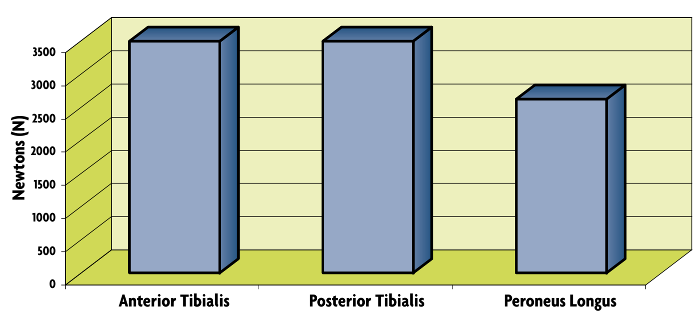
A better measure of material properties is gained by normalizing the overall tendon strength by cross-sectional area. Thus, the results shown in Figure 2 were divided by cross-sectional area and the results presented as MegaPascals (MPa) or N/mm2. The results shown in Figure 3 indicate the similarity between posterior and anterior tibialis tendons as well as the higher ultimate stress value for the peroneus longus. Note that both the posterior tibialis and peroneus longus exhibit strength that is sufficiently comparable to anterior tibialis tendons.

Figure 3. Tendon strength in Newtons per cross-sectional area



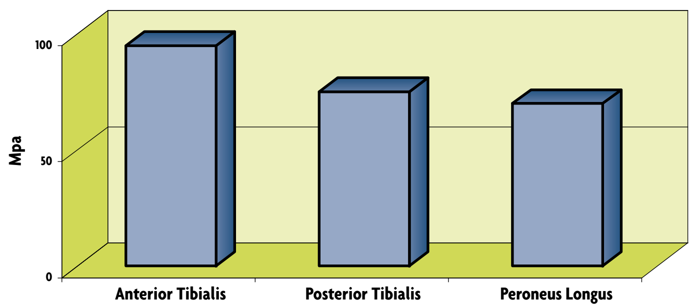
A similar study was performed by Pearsall, et al. [17] in which anterior tibialis, posterior tibialis, and peroneus longus tendons were examined. These investigators tested 16 double stranded allografts in each category. As shown in Figure 4 these grafts were all well above the maximal strengths of the native ACL shown in Table 1.

Figure 4. Tendon ultimate tensile strength



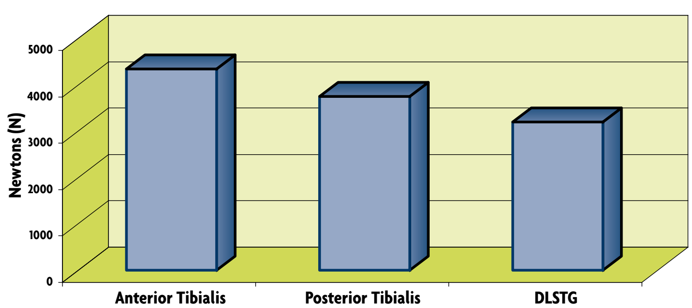
Again, the better measure of intrinsic material properties for this study is obtained by normalizing for cross-sectional area. These results are shown in Figure 5 and indicate the similarity in tissue stress between posterior tibialis and peroneus longus. It is important to recognize that the average age of donor tissues in this study was 78.3 years.

Figure 5. Tendon strength in Newtons per cross-sectional area



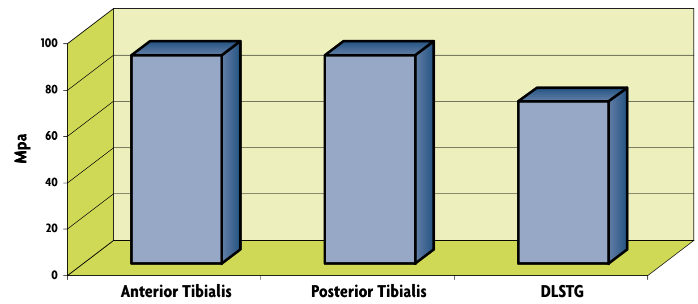
Haut Donahue, et al. [7] examined the biomechanical properties of anterior and posterior tibialis tendons and compared them to the ‘commonly used double-looped semitendinosus and gracilis (DLSTG) graft’. The results for the study of 10 tendons in each category are shown in Figures 6 and 7. As shown in Figure 6, both tibialis tendons have higher strength than the DLSTG.

Figure 6. Tendon ultimate tensile strength



As shown in Figure 7, the cross-sectional area normalized stress value indicates similar properties between anterior and posterior tibialis tendons. These results also indicate that posterior and anterior tibialis tendons of the same diameter, while having virtually identical strength to each other, would be have greater strength than the DLSTG. The authors concluded that “the structural, material, and visocelastic properties of a single loop of anterior tibialis and posterior tibialis tendon are either better than or similar to those of a DLSTG graft”.

Figure 7. Tendon strength in Newtons per cross-sectional area



Finally, Almqvist et al. [18] studied the biomechanical properties of the anterior and posterior tendon allografts in comparison to bone-patellar tendon-bone (BTB) allografts. They examined 16 each of BTB, anterior tibialis, posterior tibialis, and single looped tibialis tendons. As you can see in Figures 8 and 9, the posterior and anterior tibialis tendons exhibit similar strengths. Even though the BTBs were shown to be stronger, they were approximately 3 times the cross-sectional area of the tibialis tendon. Furthermore, the looped tibialis tendon, the configuration commonly used for ACL replacement, is much stronger than the BTB. The lower apparent strength of the tendons in this study compared to the studies presented above appears to be due to the tendon gripping method used leading to the material failure being at the grip and not mid-substance (personal communication with author). However, of more significance, is the similarity in ultimate tensile strength between the posterior and anterior tibialis tendons and also that, when normalizing for cross-sectional area that both of these grafts are stronger than the BTBs studied. These data indicate that both tibialis tendons are viable alternatives, strength-wise, to BTB allografts.

Figure 8. Tendon ultimate tensile strength

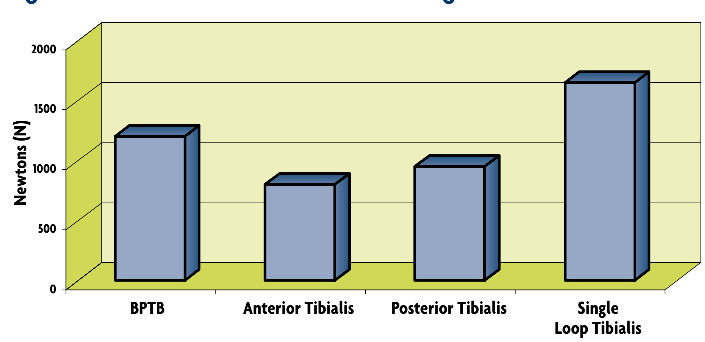
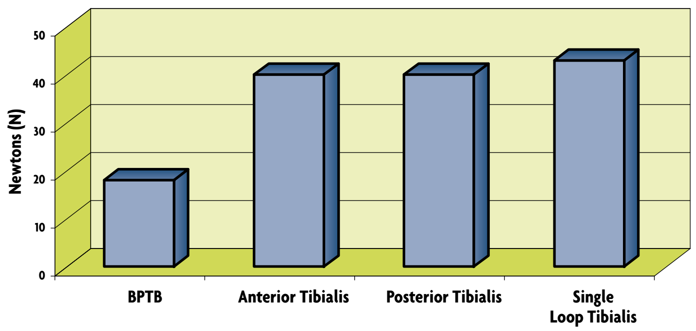


Figure 9. Tendon strength in Newtons per cross-sectional area



In summary of these 4 biomechanical studies, posterior tibialis and peroneus longus tendons are equivalent, strengthwise, to anterior tibialis tendons and should be considered as suitable for reconstructive, including ACL, procedures.

Peroneus Longus and Posterior Tibialis Tendon-Clinical Experience

According to McGuire and Hendricks,[19] "Patellar, ... tibialis (anterior and posterior), and peroneus longus tendons commonly are used in cruciate, collateral, and posterolateral corner (PLC) ligament surgery." Shino, et al. [20] have also indicated the use of peroneus tendons in ACL reconstruction.

Almqvist et al. [21] performed a long-term study using anterior and posterior tibialis tendons for unilateral arthroscopic anterior cruciate ligament (ACL) allograft reconstruction. 55 patients were included in the study and had a mean follow-up evaluation of 10 years and 6 months. The distribution of implantation between anterior and posterior tibialis was roughly 50:50 (personal communication with Author). At the time of follow-up, the median IKDC score was 97 and the median Lysholm score was 95 for these groups. They summarized "In conclusion, the tibialis anterior or tibialis posterior tendon allograft ACL reconstruction produced good clinical results in the majority of patients at long-term follow-up."

Drs. Caborn and Morgan[22] completed a two year clinical outcomes study evaluating a "single socket single bundle or single socket double bundle ACL reconstruction using tibialis or peroneus allograft with an arthroscopic bioresorbable femoral and tibial retro-screw fixation". The focus of the paper was on the method, but the use of peroneus allograft is notable.

Finally, Kerimoglu, et al. [23] specifically report on the use of peroneus longus tendon (PLT) for ACL reconstruction. The study included 29 patients and used autografts and interference nail fixation. Fourteen of the patients also had partial meniscectomy. The mean Lysholm score was 83.7 and was compared with the contralateral normal knee. They reported "no flexion or extension losses occurred in the affected knees." The study authors conclude that "PLT can be an appropriate autograft source for ACL reconstruction".

Conclusion

While the anterior tibialis tendon is a widely used and studied allograft for ACL reconstruction, little has been presented regarding the use of the anatomically and structurally similar posterior tibialis and peroneus longus. Here, we have summarized literature related to the biomechanical properties of these grafts and reports regarding clinical uses of posterior tibialis and peroneus longus. The biomechanical studies all demonstrate the sufficient clinical strength of the posterior tibialis and peroneus longus when compared to the anterior tibialis and to clinically relevant benchmarks. Taken together, both the posterior tibialis and peroneus longus grafts are considered appropriate tendons for sports medicine reconstructive procedures.

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