

# Changes in Patellar Tendon Structure after Bone-Patellar Tendon-Bone Autograft ACLR Relates to Knee Extensor Strength

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**INTRODUCTION:** Individuals who undergo an anterior cruciate ligament reconstruction (ACLR) with a bone-patellar tendon-bone (BPTB) autograft often exhibit anterior knee pain and slower recovery of quadriceps strength. After ACLR-BPTB autograft, the graft site initially demonstrates an increased cross-sectional area (CSA) as the tendon gap is filled with disorganized collagen. However, little is known about patellar tendon remodeling within the first year post-ACLR and as a key component of the knee extensor mechanism, if changes in tendon structure relate to post-ACLR quadriceps strength. Therefore, the purposes of this study were to: i) determine if patellar tendon structure differs between preoperative and 12-months post-ACLR assessments and ii) if patellar tendon remodeling within the first year post-ACLR relates to quadriceps strength at 12-months post-ACLR. We hypothesized: i) the patellar tendon would demonstrate an increase in CSA across the length of the tendon from preoperative to 12-months post-ACLR and ii) a greater increase in patellar tendon CSA would be associated with greater quadriceps strength.

**METHODS:** This study was approved by the Institutional Review Board and all participants provided informed consent. Individuals who underwent ACLR with BPTB autograft were evaluated as a part of this retrospective analysis of a larger longitudinal study. MRI images were collected in the ACLR limb preoperatively and 12-months post-ACLR using a Siemens Magnetom Prisma 3T scanner. Dual Echo Steady State (DESS) sequences were transformed with the patellar tendon vertical in the sagittal plane. Patellar tendon CSA was measured as total area within the tendon sheath at 25%, 50%, and 75% of the tendon length (distal most patella to most proximal insertion on tibia) and normalized to body mass (cm<sup>2</sup>/kg). Maximal isometric knee extension torque was assessed 12-months post-ACLR at 90° of knee flexion using an isokinetic dynamometer. Participants completed a series of submaximal knee extension exercises followed by at least two maximum effort trials of three seconds. Peak knee extension torque was calculated and normalized to body mass (Nm/kg). Separate paired t-tests were used to evaluate changes in patellar tendon CSA at 25%, 50%, and 75% tendon length between preoperative and 12-months post-ACLR timepoints. A linear regression analysis was performed to assess the relationship between increase in patellar tendon CSA from preoperative to 12-months post-ACLR and knee extensor torque at 12-months post-ACLR.

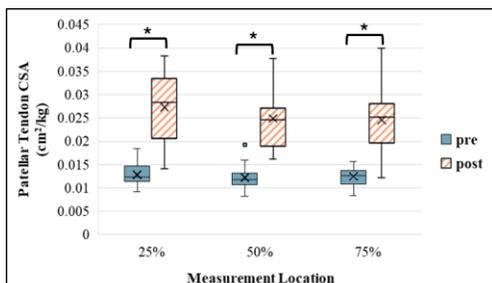
**RESULTS SECTION:** Nineteen participants with ACLR with BPTB autograft (9 Female; 20.7±3.5 years; height: 1.76±0.09 m; pre-operative mass: 74.9±12.1 kg) were included in this study. Patellar tendon CSA significantly increased at all measurement locations from preoperatively to 12-months post-ACLR (25% length: p<0.001, d=2.21; 50% length: p<0.001, d=1.66; 75% length: p<0.001, d=1.76; FIGURE 1). After removing one outlier, a larger increase patellar tendon CSA at 50% tendon length 12-months post-ACLR was strongly related to greater knee extensor torque at 12 months (r=0.667, p=0.002; FIGURE 2). There were no significant associations between increase in patellar tendon CSA at 25% and 75% tendon length and knee extensor torque at 12 months (25%: r=0.330, p=0.181; 75%: r=0.405, p=0.096).

**DISCUSSION:** Patellar tendon structure significantly increased in size preoperatively to 12-months post-ACLR with BPTB autograft across the length of the tendon. Notably, there is large between-subject variability in the patellar tendon size postoperatively compared to preoperatively, observed in Figure 1. Additionally, a larger increase in patellar tendon CSA at the patellar tendon midpoint preoperatively to 12-months post-ACLR related to greater knee extensor torque. While this study is important in demonstrating the relationship between tendon structure and knee function post-ACLR, we are unable to determine the mechanistic relationship between increased tendon CSA and strength. It remains unclear if increasing patellar tendon CSA allows for greater knee extension strength post-ACLR or if greater knee extension strength recovery provides the tendon tissue with the loading needed to increase the tendon CSA. Further studies are needed to examine mechanisms underpinning relationships between structure and function.

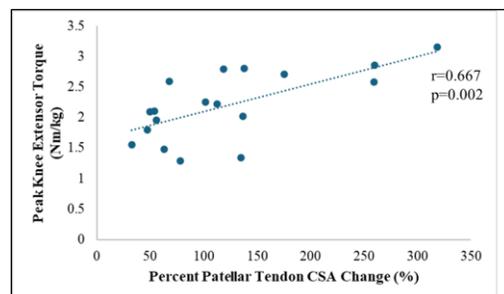
**SIGNIFICANCE/CLINICAL RELEVANCE:** Within the first 12 months post-ACLR with BPTB autograft, patellar tendon midsubstance remodeling with increased CSA may be a necessary compensatory mechanism for impaired graft site composition and collagen organization and needed for transferring greater forces for performing knee extension. Targeted treatment of patellar tendon loading post-ACLR with BPTB autograft may be necessary to optimize postoperative knee extension strength and thus, mitigate re-injury and post-traumatic osteoarthritis risk.

**REFERENCES:** 1. Poehling-Monaghan KL et al. *Orthop J Sports Med.* (2017)  
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**FIGURE 1.** Change in patellar tendon cross sectional area (CSA) at 25%, 50%, and 75% patellar tendon length from preoperatively to 12-months post-ACLR with BPTB autograft. x indicates mean value, \* indicates significance (p<0.05)



**FIGURE 2.** Relationship between increase in patellar tendon cross sectional area (CSA) at 50% patellar tendon length from preoperative to 12-months post-ACLR and peak knee extensor torque 12-months post-ACLR with BPTB autograft.