Patellar Bone-Tendon-Periosteum Grafts – An Alternative ACL Graft Choice for the Skeletally Immature?

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Purpose: Describe a novel technique to harvest the patellar bone-tendon-periosteum and compare the mechanical properties of this graft to the quadriceps tendon, ACL, and PCL.

Methods: Skeletally immature fresh frozen whole knees from 18 human cadavers (mean specimen age = 10.4 years) were thawed and the ligaments grossly dissected. Cruciate ligaments were tested as a single unit and the QT was tested as a 1 cm wide column dissected from the tendon midline with a distal patellar bone block. For the BTP, the central 10 mm tibial tendon insertion was elevated and a 2 cm length (or at least 0.25 of the graft length) of insertional fibers and periosteum were sharply elevated from the apophyseal cartilage, with care taken to avoid depth at the peri-chondral physeal level. Each specimen was secured in an MTS machine and underwent a tensile loading protocol to measure tensile strength, tensile strain, stiffness, and linear modulus.

Results: The QT demonstrated tensile strength of 6.1 ± 2.5 MPa, tensile strain of 35.0 ± 9.4%, stiffness of 73.6 ± 37.0 N/mm, and a linear modulus of 36.5 ± 20.5 MPa. Comparatively, the BTP showed higher tensile strength (10.8 ± 4.7 MPa), lower tensile strain (29.4 ± 10.7%), higher stiffness (86.9 ± 32.5 N/mm), and a higher linear modulus (83.9 ± 37.4) than the QT. The ACL exhibited tensile strength of 7.9 ± 3.3 MPa, tensile strain of 53.7 ± 21.7%, stiffness of 68.4 ± 41.9 N/mm, and a linear modulus of 33.3 ± 22.3 MPa, while the PCL demonstrated values of 9.1 ± 5.7 MPa, 47.0 ± 22.7%, 98.0 ± 73.0 N/mm, and 52.3 ± 54.2 MPa, respectively.

Conclusion: The BTP graft showed significantly higher tensile strength ($P<0.01$) and linear modulus than the quadriceps ($P<0.01$), with no significant differences in stiffness or tensile strain. When compared to the ACL, the BTP demonstrated significantly higher linear modulus ($P<0.01$) and significantly lower tensile strain ($P<0.01$), with no significant differences in stiffness or tensile strength. Finally, the BTP demonstrated significantly lower tensile strain ($P=0.01$) than the PCL, with no significant differences in the linear modulus, stiffness, or tensile strength.

Clinical Significance: The QT currently serves as a reasonable graft for ACL reconstruction. With superior mechanical properties, such as tensile strength and linear modulus, a patellar bone-

tendon-periosteum (BTP) construct can also serve as a reasonable graft for primary or revision ACL reconstruction.

Table 1

Results for Pediatric Cruciate Ligaments and Candidate Graft Tendons

	n	Linear Modulus (MPa)	Stiffness (N/mm)	Tensile Strain (%)	Tensile Strength (MPa)
BTP	18	83.9 ± 37.4	86.9 ± 32.5	29.4 ± 10.7	10.8 ± 4.7
Quadriceps	17	36.5 ± 20.5	73.6 ± 37.0	35.0 ± 9.4	6.1 ± 2.5
ACL	11	33.3 ± 22.3	68.4 ± 41.9	53.7 ± 21.7	7.9 ± 3.3
PCL	10	52.3 ± 54.2	98.0 ± 73.0	47.0 ± 22.7	9.1 ± 5.7
P values					
BTP vs Quadriceps		**<.01**	.26	.10	**<.01**
BTP vs ACL		**<.01**	.19	**<.01**	.08
BTP vs PCL		.08	.57	**.01**	.39

Data are shown as mean ± standard deviation. P values in **bold** are statistically significant (P<0.05).

BTP, patellar bone-tendon-periosteum; ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.