THE EFFECT OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING PATELLA TENDON BONE GRAFT ON THE IN VIVO MUSCLE-TENDON MECHANICAL PROPERTIES AND KNEE JOINT FUNCTION

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Introduction

One of the most common grafts used for reconstruction of the anterior cruciate ligament (ACL) is the central third of the patellar tendon (PT). In vitro studies on animal tendon have shown that removal of the central third of the tendon caused a significant reduction in the stiffness and ultimate load to failure of the remaining tendon for up to 6 months post surgery [Kamps, 1994]. However, recent studies have shown that the stiffness of the human PT is restored after graft harvesting for ACL reconstruction [Reeves, 2009]. Therefore the purpose of this study was to investigate the effect of graft harvesting on in vivo mechanical properties of the patellar tendon and knee joint function.

Methods

Eight participants were selected who had undergone ACL reconstruction using the PT bone graft (5 males and 3 females; 38.4±13.8 years, 77.1±9.6 kg and 1.72±0.06 m). All participants were between 5 and 10 years post surgery. The PT mechanical properties were assessed in vivo using both dynamometry and ultrasound (US) imaging. Knee extensor torque, voluntary activation (VA), cross-sectional area (CSA), vastus lateralis (VL) fascicle length and pennation angle and PT moment arm were also assessed. Patellar tendon stiffness was calculated from the gradient of the tendon force-elongation curve. Tendon stiffness was normalized to the tendon dimensions (length and CSA) to obtain the Young's modulus. To obtain PT mechanical properties the full tendon was imaged with a long US probe that enabled the experimenter to estimate the elongation while viewing both ends of the tendon. The tendon CSA was estimated from axial plane MRI scans which clearly demarcated the tendon borders.

Results

The CSA of the operated PT was 36% larger than that of the uninjured tendon (Table1). Patella tendon stiffness was not significantly different between the operated and the uninjured control tendons, but the Young's modulus was significantly lower by 25% when compared to the control tendon. In all previous studies the tendon stiffness has been obtained by using a short US probe, but we used a long probe which showed that the stiffness was significantly different from that estimated by using the short probe. The physiological CSA of the VL muscle was assessed using MRI and was similar between the operated and the uninjured sides. The VA capacity of the extensors was comparable between sides.

Tendon	Operated	Uninjured
Stress MPa)	36.4±5.9*	49.6±8.9
Strain (%)	10.7±2.6	11.3±3.2
Stiffness ($N \cdot mm^{-1}$)	1000±284	1043±238
Young's Modulus (GPa)	0.35±0.2*	0.46±0.16
Length (mm)	45.1±6.2	45.2±7.2
CSA (mm^2)	143±31.4*	105±16.8
RTD ($Nm \cdot s^{-1}$)	739.5±361	732±385.3

*Table 1: Patellar tendon mechanical properties for operated and uninjured side (*p<0.05).*

Discussion

In a post-operative period between 5-10 years from the ACL reconstruction the maximal isometric knee extension torque, the quadriceps muscle morphology and architecture were similar between the operated and uninjured sides. The results clearly demonstrated a recovery of the knee extensor muscle–tendon unit after graft procurement from the patellar tendon for ACL reconstruction. Therefore, the results of the present study are promising for both the surgeons performing ACL reconstruction using the patellar tendon bone graft and their patients.

References

Kamps *et al,* Am J Sp Med 22: 803-811, 1994.

Reeves *et al,* J Biomech, 42:797-803, 2009.