Program: Master Biomedical Engineering

Master Thesis

Title: The Effect of Initial Graft Force Loss on the Stability in Anterior Cruciate Ligament Reconstruction

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Abstract:

The initial fixation strength of anterior cruciate ligament reconstruction (ACLR) grafts is essential to avoid graft elongation and secure the graft in place within the bone tunnel for biological incorporation. A sufficient time-zero graft tension is needed to eliminate initial knee laxity and graft slippage. Studies have shown that the time-dependent viscoelasticity of tendon grafts leads to a postoperatively decreasing intra-articular graft force (IAGF) resulting in a loss of fixation strength. Current literature on time-dependent graft tension loss with tibial screw fixation concluded that the amount of force decrease raises substantial questions regarding the remaining fixation strength. However, comparative biomechanical data on the time-zero and time-delayed cyclic graft stability are currently unknown. Moreover, no information are currently available in this area on all-inside grafts with adjustable loop fixation.

The primary aim of this study was to investigate the effect of time-zero graft tension on the biomechanical stability of grafts for all-inside ACLR and with tibial interference screw fixation in an in vitro full-construct model. The second aim was to measure the IAGF, over the course of 16 hours, in soft tissue grafts for all-inside ACLR and with tibial interference screw fixation to evaluate the effect of the time-dependent graft tension loss on the biomechanical stability when compared to time-zero graft tension reference groups.

Quadrupled bovine tendon grafts (9 mm in diameter) were either fixed with interference screws or ALD suspension (TightRope II) in porcine tibiae. Specimens (n = 8 each group; N = 64 constructs tested) were subjected either to a high or low tension protocol and time-zero or time-delayed (after 16 hours) testing. The testing included pretensioning, preconditioning with retensioning and 3000 cycles of position-controlled dynamic loading at 1 Hz with peak loads of 250 N including complete unloading, followed by a pull to failure (50 mm/min). The IAGF loss, construct elongation, ultimate strength and stiffness were analyzed.

Overall, a significant IAGF loss over 16 hours was observed for all groups. However, a higher initial IAGF of 200 N compared to 100 N resulted in significantly higher remaining IAGF after 16 hours. Furthermore, the results show that a higher IAGF after graft fixation led to significantly smaller initial elongation. No significant differences were found for the total elongation and ultimate strength after time-zero and time-delayed testing.

The results show that a higher tensioning force better compensates graft tension loss. Additionally, time-dependent graft tension loss due to the viscoelastic behavior of soft tissue is uncritical for the ACLR graft fixation strength and already included in time-zero stability testing as part of the total elongation. Thus, time-zero stability evaluation should be sufficient and representative to demonstrate the fixation strength of various grafts for ACLR.