EFFECT OF TUNNEL-GRRAFT LENGTH ON THE BIOMECHANICS OF ACL RECONSTRUCTED KNEES

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INTRODUCTION
Reconstruction of the anterior cruciate ligament (ACL) with autologous tendon grafts is a well accepted operative technique and aims to reestablish normal knee function. Tendon-to-bone healing of hamstring grafts requires an extended time for graft incorporation. To increase the diameter of the graft, soft tissue grafts may be looped to 3- or 4-stranded grafts thereby reducing the length of the graft-tunnel interface. Therefore, the objective of this study was to evaluate the influence of graft length within the femoral tunnel on tendon to bone healing in ACL reconstructions using a soft tissue graft in an intra-articular goat model.

METHODS
ACL reconstructions using a soft tissue graft were performed in 36 knees in a goat model in a bilateral approach and the knees were biomechanically evaluated at six and twelve weeks. In both groups the graft was fixed using an Endobutton technique and in Group 1 (n=15) a 15 mm and in Group 2 (n=17) a 25 mm graft was pulled into the femoral tunnel. The diameter of the ACL replacement graft was determined using a 3D scanning device (Digitibot III). The anterior tibial translation and the in situ forces of the replacement graft were determined using a robotic/UFS testing system. (Stäubli RX-90, Fig.1a). Afterwards the femoral fixation was reharvested and mechanical properties were determined using a uniaxial testing machine. The axis was aligned in line with the femoral tunnel to imitate a worst case scenario (Fig.1b). The resulting load-elongation curve was documented as well as the ultimate failure load, elongation at failure, yield load, and the mode of failure. Stiffness was determined as the linear region of the load elongation curve and the ultimate stress was calculated. Overall 15 mm and in Group 2 (n=15) a 25 mm graft was pulled into the femoral tunnel. The diameter of the ACL replacement graft was determined using a 3D scanning device (Digitibot III). The anterior tibial translation and the in situ forces of the replacement graft were determined using a robotic/UFS testing system. (Stäubli RX-90, Fig.1a). Afterwards the femoral fixation was reharvested and mechanical properties were determined using a uniaxial testing machine. The axis was aligned in line with the femoral tunnel to imitate a worst case scenario (Fig.1b). The resulting load-elongation curve was documented as well as the ultimate failure load, elongation at failure, yield load, and the mode of failure. Stiffness was determined as the linear region of the load elongation curve and the ultimate stress was calculated. In the intact group ultimate stress and stiffness were significantly higher than intact. Overall, the 25 mm case was shown to have more anterior tibial translation than the 15 mm case (p<0.05).

RESULTS
With regard to the cross sectional area no statistical significant differences were found (p>0.05). The anterior tibial translation shown in figure 2 of both groups (15 and 25 mm in the tunnel) of the ACL reconstructed knees was significantly less than the ACL deficient knees, but significantly higher than intact. Overall, the 25 mm case was shown to have more anterior tibial translation than the 15 mm case (p<0.05).

DISCUSSION
In a clinical setting the surgeon can increase the diameter of the soft tissue graft by looping the graft to a 3- or 4-stranded graft. This may be especially of high interest for anatomical ACL reconstructions restoring the two bundles of the ACL separately. In this situation the total graft length available for reconstruction may be limited. The aim of the current study was to investigate the correlation of tunnel length within the femoral tunnel and its effects on joint kinematics as well as mechanical properties of the tendon-to-bone interface in an intra-articular healing model. The results suggest that there are no statistical significant differences in mechanical properties such as yield load, maximum load and stiffness. In terms of anterior tibial translation the 15 mm case was not increased compared to the 25 mm case. Furthermore, the mechanical properties of ACL reconstructions in an intra-articular goat model are significantly lower when compared to the intact ACL.

These results underline the fact that after 6 weeks the graft incorporation is still reduced due to the remodeling processes of the graft. This basic science data further emphasizes the need for a defensive rehab program after ACL reconstructions using a soft tissue graft.

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