Biomechanical experiments on artificial ligaments for the ACL reconstruction

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1 Introduction

The rupture of the anterior cruciate ligament (ACL) is common in sports such as skiing, football and basketball; this pathology usually occurs as a result of a violent twist of the knee. When a ligament is torn it can either be repaired or replaced. The first use of synthetic material for ligament replacement was proposed in the 1980's. Poor results and high rates of failure were reported, because the used materials had not achieved the expectations to be met by this type of prostheses [1].

In this work, we evaluated a new generation of artificial ligament which prevents the onset of acute aseptic synovitis. The proposed Ligament Advancement Reinforcement System (LARS), consists of 44 fibers of PETG (polyethylene terephtalate glycol). It could be grafted with a bioactive polymer that can control the cellular responses.

The purpose of this study was to perform a biomechanical analysis of artificial ligaments, implanted during three months in ewe.

2 Methods

Fourteen ewes were implanted, one knee received the LARS ligament in place of the native ligament. The contralateral knee allowed to make comparisons. The 14 ewes were divided into two groups of 7 ewes: one group received the artificial ligament grafted with a bioactive polymer and the other group received the artificial ligament without grafting.

The ewes were followed-up to detect the presence of lameness or other problems that could invalidate the results.

The tested ewe's stifles included the synovial capsule in its integrity, femur, tibia, the patella and a portion of the quadricipital tendon. They were kept frozen at -20 ° C, and were thawed 24 hours before the experiments.

The biomechanical experiments were performed on the stifles three months after their implantation and are the following:

- A kinematics analysis (flexion-extension), in order to characterize the relative movements of the knee joint. During this experimentation, the femur was fixed while the tibia followed the physiological movement imposed by the traction of the quadricipital tendon (see figure 1.a). The test was conducted for 6 cycles at speed of 50mm /min.
- A laxity test which allowed assessing the joint stability for an anterior traction and for the varus-valgus test (see figure 1. b). During this test, 6 cycles of loadings were made to reach a tensile force of 100N on the tibia.
- A destructive test (fig 1.c) to assess the anchorage strength of the implant.

3 Results and Discussion

For the flexion-extension analysis some example results are given figure 2. During this movement, the varus-valgus rotation (Rx) was not significantly different between non-implanted and implanted stifles (figure 2. a). For all translations Tx, Ty and Tz, the trend curves of implanted and non- implanted members were similar. But more displacement of the tibia of the implented limbs was observed.(figure 2. b).

The laxity of the implanted stifles seemed much larger than the one of the healthy stifles (see figure 3), but, the implanted stifles exhibited an important displacement when the stress increased.

The failure load of the native ligaments was much higher than the one of the grafted ligaments; the obtained values were 1276.5 ± 52.4N and 188.4 ± 52.4N respectively. However, grafted ligaments presented better results than the non-grafted one.

Markolf stiffness also presented a significant gap: 333.5 ± 66.6N/mm for the native ligament, 188.4 ± 52.4N/mm for the grafted artificial ligaments and 113 ± 70.1N/mm for the non grafted one.

These results are preliminary. Indeed, it was noticed that two artificial ligaments over the seven (in the non-grafted group) were damaged over 50% before the biomechanical experiments. This could affect the previous results.

4 Conclusions

The experiments were carried out on 28 ewe's stifles, 3 months after their implantation and provided significant biomechanical parameters which helped us for the assessment and the characterization of the artificial ligaments.

The native ligament gives better results of relaxation, stiffness and failure load than the artificial ligament. However, the results between the grafted artificial ligaments and non grafted ones are encouraging for the grafting.

These results are still preliminary; they will be completed by other experiments on the ewe's knees after 12 months of implantation.

References

[1] Nau T., Lavoie P., and Duval N., A new generation of artificial ligaments in reconstruction of the anterior cruciate ligament: Two-year follow-up of randomised trial. *Journal of Bone and Joint Surgey*, April 2002, 356-360.

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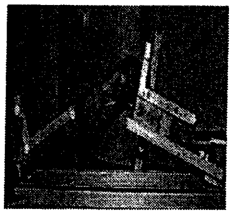
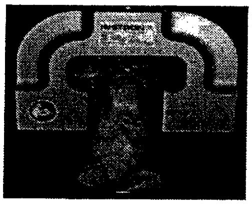


(a) (b)



(c)

Figure 1: Test device for the ewe stifle: a) flexion- extension, b) anterior laxity and varus-valgus test, c) destructive test.

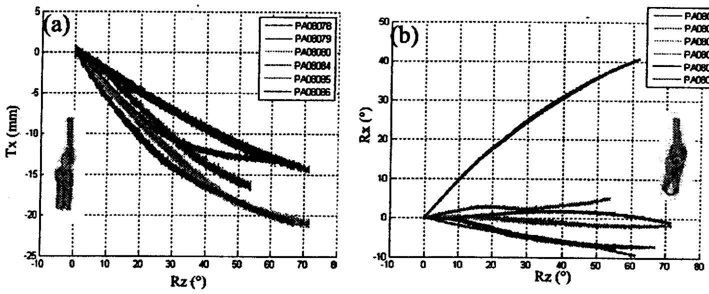


Figure 2: Some result curves of: a) effort translation (Tx) according to flexion angle (Rz), b) varus-valgus rotation (Rx) according to flexion angle (Rz).

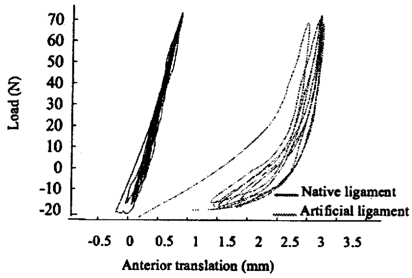


Figure 3: Laxity test: anterior-posterior load according to tibial translation (Tx).