Functional evaluation of anterior cruciate ligagment autografts in pre-clinical animal models

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Introduction

Rupture of the Anterior Cruciate Ligament (ACL) affects about 1 person over 3000 every year. The current standard care is based on ligament reconstruction by autograft from tendon tissues and is considered as the gold standard. Yet, autograft reconstruction presents serious limitations. Recent developments in artificial ligaments are promising and could potentially address the currently growing demand from surgeons and patients for an off-the-shelf alternate solution. However, before these can be commonly used in clinical routine, their biocompatibility and biomechanical performance for the short and long terms must be studied in pre-clinical animal models. Building upon the work of [1], we propose in this contribution a methodology for assessing the biomechanical performance of artificial ligaments, and to provide reference data (autografts) using an animal model (sheep) at 3 months after implantation.

Materials and Methods

Surgery and specimen preparation

14 fresh frozen lower limbs were used in this study, seven left (autograft implantation) and seven right (contralateral) knees. These were harvested from seven sheep sacrificed 3 months after implantation. The biomechanical analysis of the knees consisted of four successive in vitro experiments: three kinematics tests (flexion-extension, varus-valgus laxity and anterior drawer tests) and a pull-out destructive test.

Kinematics analysis: flexion-extension and laxity tests

The kinematic analysis was performed using specific motorized devices adapted from previously described and validated ones [1]. The protocol combined motion analysis of tripods screwed in the bony structures and 3D personalized reconstruction (figure 1) from low-dose X-ray system (EOS, EOS Imaging, Paris, France) [1,2,3,4].

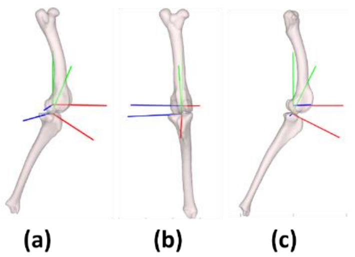

Figure 1: *Anatomical frames defined for each bone (a) Profile (b) Frontal and(c) oblique views respectively.*

Pull-out destructive tests

The pull-out tests were performed using an INSTRON 5566 testing machine (Instron Ltd., Buckingham-shire, England) instrumented with a 5 kN load cell. After conditioning, a tension load was applied to the specimen (5 mm/min) until total failure.

Data analysis: mobility assessment and statistical tests

The following parameters were extracted to allow the comparison with the literature [1] (i) Internal rotation Ry (°) value for a 40° flexion angle (Ry_40), (ii) Anterior Tibial Translation (mm) for 100 N loading (ATT_100), (iii) Varus Valgus amplitude (°) at 4 Nm loading (VV_4) and (iv) the Failure load (N) (FL).

Results and discussion

Table 1 below summarizes the results :

mean ± SD.	Current study		Guerard et al. [1]	
	Contralateral knees	Autograft (3 months)	Contralateral knees	**LARS (3 months)**
Ry_40	-14.9 ± 2.1 (n=7)	-10.8 ± 4.0 (n=7)	-14.5 ± 3.1 (n=4)	-9.8 ± 2.6 (n=4)
ATT_100	0.9 ± 0.2 (n=7)	2.8 ± 0.9 (n=7)	0.6 ± 0.5 (n=5)	2.8 ± 1.7 (n=6)
VV_4	9.9 ± 4.6 (n=7)	15.2 ± 2.2 (n=7)	12.0 ± 3.8 (n=4)	12.9 ± 2.2 (n=6)
FL	912 ± 145 (n=7)	183 ± 80 (n=7)	1214 ± 286 (n=6)	144 ± 69 (n=5)

Table 1: Kinematic results and failure loads

The results shows a good consistency for kinematic parameters of the contralateral knees. The failure load was clearly different due to the interindividual variability. As concerns the autograft, a reduction of internal rotation during the flexion motion and an increase of the laxity in ATT could be observed. The failure load was also decreased for the grafted knee.

References

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