Research of a new synthetic implant fixation interface material used for cranial cruciate ligament repair in dogs: The choice of Nylon?

Nicolas Giraud, Bastien Goin, Yoann Lafon, Michel Massenzio, Eric Viguier, Thibaut Cachon

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N. Giraud[a], B. Goin[a,b,c], Y. Lafon[c], M. Massenzio[c], E. Viguier[a] and T. Cachon[a*]

[a] *Université de Lyon, VetAgro Sup, Service de chirurgie des petits animaux, Interactions Cellules Environnement (ICE), Marcy l'Etoile, France;* [b] *Novetech Surgery, Monaco;* [c] *Univ Lyon, Université Claude Bernard Lyon 1, Univ Gustave Eiffel, IFSTTAR, LBMC UMR_T 9406, F69622 Lyon, France*

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1. Introduction

The cranial cruciate ligament (CCL) rupture is one of the most common orthopedic affections in dogs (Hayashi et al. 2004). Nowadays, the surgical management of this orthopedic disorder concerns a tibial osteotomy to modify the biomechanical conformation of the stifle (von Pfeil et al. 2018). However, these last surgical treatments do not respect the physiological insertions of the CCL which could be one of the explanations for the long-term complications of these techniques (Krotscheck et al. 2016). During last decade, a renewed interest has been observed in the field of veterinary surgery concerning intra-articular reconstruction of CCL techniques, either by allograft, or by synthetic implant. The challenge of these two types of CCL reconstructions relies on finding a fixation technique respecting the stabilization function of the stifle and its biocompatibility over the long term. In particular, the synthetic CCL reconstructions using Ultra-High Molecular Weight Polyethylene (UHMWPE) implants yields to excellent results regarding the biocompatibility (Smith et al. 2019). And the recent published studies on improving the fixation system underline promising results (Blanc et al. 2019; Goin et al. 2019; Rafael et al. 2020). Following the same research field, authors hypothesize that the use of a fixation interface between the interference screw and the bone could increase the pull-out strength of the fixation system. The aim of this *ex-vivo* biomechanical study was to test this hypothesis with a titanium interference screw inserted through a nylon dowel as femoral fixation used for synthetic reconstruction of the CCL in dogs.

2. Methods

2.1. Sample preparation protocol

Eight stifles were harvested from 4 cadaveric dogs between 25 and 35 kg. All dogs were of similar breed and died from reasons unrelated with this study. Femoral parts were disarticulated from the tibias and all soft tissues were removed to let intact only the femur bones. Then, femoral parts were transected at the level of diaphysis to allows its inclusion into a metallic mold (7x3x3 cm) filled with resin (Goin et al. 2019).

2.2. Implantation of the UHMWPE ligament

A femoral tunnel (Ø6 mm) was drilled from the caudo-lateral femoral insertion of the physiologic CCL. The UHMWPE implant (Novalig 8000, Novetech Surgery, Monaco) was passed through the tunnel. Then, a nylon dowel (Ø6 mm, 30 mm-long) (Fischer, Strasbourg, France) was inserted into the tunnel from the distolateral femoral metaphysis to intra-articular area. Finally, an interference screw (Ø5mm, 20 mm-long) was implanted inside the nylon dowel following the same insertion protocol than the nylon dowel (Fig.1).

2.3. Biomechanical testing

The static tensile test protocol and biomechanical setup were inspired by Goin et al. 2019. The samples were pre-loading at 10N (20 mm/min), before started the traction pull-out test to failure at 1 mm/min. The femoral samples were maintained proximally into a stirrup by an 8-mm pin through the metallic mold, while the UHMWPE implants was inserted into a mechanical grip mounted on the mobile traverse of the traction machine (Fig.1).

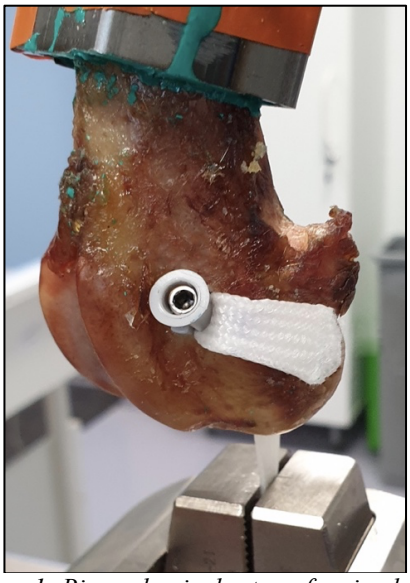

Figure 1: Biomechanical setup of an implanted femoral sample and placed into the testing machine.

2.4. Data processing

Linear stiffness was defined by calculating the slope of the load displacement curve in its linear interval for each tensile test. Failure load was designed as the maximum force measured during each test. Load for 3 mm of displacement has been chosen as the output parameter according a previous study (Rafael et al. 2020).

3. Results and discussion

Sample	Load for 3 mm of displacem-ent (N) (L3mm)	Maximum strength (MS)		Linear stiffness (N/mm)
		Load (N)	Displacem-ent (mm)	
N°1	124	508	9,6	60
N°2	41	517	10,2	88
N°3	159	325	5,2	75
N°4	125	279	6,3	47
N°5	59	336	8,2	79
N°6	221	563	6	134
N°7	191	226	4,3	45
N°8	82	411	8,4	70
Mean	125	396	7,3	75
SD	63	123	2,1	28

Table 1: Results of the eight quasi-static tensile tests.

No rupture of the UHMWPE implant was reported. The failure mode was the same among each test: progressive slippage of the UHMWPE implant through the femoral tunnel at the bone, UHMWPE implant, nylon dowel (dilatated by an interference screw) interface. The dispersion of the results for the output parameter L3mm shows that the femoral fixation system does not reported constant and homogeneous biomechanical strengths for all performed tests. Results for each biomechanical output parameter studied (Table 1) were lower than previous studies (Blanc et al. 2019; Rafael et al. 2020). A strict comparison with these results was not possible because tensile tests were performed on a complete fixation system of the UHMWPE implant (femoral and tibial part) (Blanc et al. 2019; Rafael et al. 2020), while in the present study, only femoral fixation was tested. However, the failure mode reported in these studies (Blanc et al. 2019; Rafael et al. 2020) was in agreement with our results. We can classified the utilization of an nylon dowel dilatated by an interference screw for synthetic LCC fixation system as the lower pull-out strength than only interference screws secured the UHMWPE implant following "Out-In" surgical technique i.e. maximum strength reported (335 ± 59 N) (Blanc et al. 2019). Finally, the higher pull-out strength results were obtained with interference screws secured the UHMWPE implant following "In-Out" technique ie maximum strength reported (509 ± 124 N) (Rafael et al. 2020).

4. Conclusions

This study shows that the utilization of a nylon dowel interface dilatated by an interference screw against an UHMWPE implant does not allow to obtain satisfactory pull-out strength compatible with LCC synthetic reconstruction for dogs.

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***Corresponding author. Email: thibaut.cachon@vetagro-sup.fr**