Biomechanical analysis of an extra-articular stabilization using a synthetic implant for craniodorsal hip luxation repair in a feline cadaver model: preliminary results

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1. Introduction

Coxofemoral luxation is a common traumatic lesion in small animals. The surgical management of hip luxation consists in various hip stabilization techniques, including capsulorrhaphy, extra-articular ilio-femoral suture (Meij et al. 1992) secured with anchors (Spranklin et al. 2006) and intra-articular replacement of the femoral head ligament with a synthetic ligament secured by toggle pins (Flynn et al. 1994). The choice of surgical treatment depends on the type of hip luxation, which occurs usually in a craniodorsal direction and more rarely in a caudodorsal or caudoventral direction (Brinker et al. 1983). These stabilization techniques and the physiologic hip joint strength that they confer have already been tested biomechanically in dogs but data on cats is scarce (Flynn et al. 1994; Baltzer et al. 2001). The aim of this study was to evaluate the biomechanical strength of an extra-articular stabilization technique using a UHMWPE implant secured by an interference screw for craniodorsal hip luxation in a feline cadaver model.

2. Methods

2.1. Sample preparation protocol

Four left hip joints were harvested from four feline cadavers weighing between 3.5 and 4.5 kg. The cats had died of causes unrelated with this study. Soft tissues were removed, except the hip articular capsule and the femoral head ligament. Femoral parts were transected at the level of the distal metaphysis to facilitate their normalized inclusion into a metallic mold (15x100 mm), already assembled with a universal joint (20 mm) in its distal part (Flynn et al. 1994).

2.2. Implantation of the UHMWPE ligament

After performing a controlled 5-mm long incision of the hip joint capsule in the craniodorsal area and transecting the femoral head ligament, cadaveric hip joints were stabilized with a UHMWPE implant (Novalig 2000 Platine, Novetech Surgery, Monaco). A 4-mm wide ilium tunnel was drilled at 10 o'clock dorsally to the origin of the articular coxal muscle and the rectus femoris muscle, close to the joint. The cortical button of the UHMWPE implant was inserted latero-medially and secured to the inner cortical part of the ilium (Figure 1a). A second 2.5-mm bone tunnel was drilled from the level of the greater trochanter in a lateral (center of the origin of the vastus lateralis) to medial (dorsal and close to the neck) direction. A third 2.5-mm bone tunnel was drilled in a latero-caudal to cranial direction of the femoro-proximal metaphysis. The entry point was defined as the caudal part of the vastus lateralis origin, next to the gluteal tuberosity (on the linea aspera), and the exit point was centered on the sagittal plane of the cranial part of the diaphysis (Figure 1b). The third tunnel was tapped (Ø3 mm). The UHMWPE implant was passed through the second and third tunnels and tightened with a zero version angle to the hip (mild internal rotation and abduction of the femur) and secured with a 3x11-mm interference screw (Novetech Surgery, Monaco) (Figure 1c).

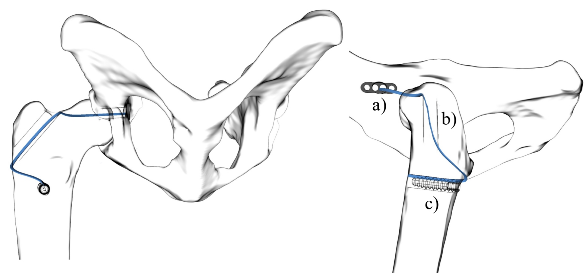

Figure 1: Diagram of the extra-articular hip joint stabilization using a UHMWPE implant for craniodorsal hip luxation.

2.3. Biomechanical testing

Cadaveric hemipelves were fixed on specific biomechanical bases made by 3D printing. A 3D reconstruction of cadaveric pelvises from CT scan imaging was used to perform the hip joint placement onto the biomechanical bases in physiologic weight-bearing condition (hip joint flexor angle of 120) (Guillot et al. 2015). Femoral diaphyses were placed in adduction (15° angle) to reproduce the condition of physiologic craniodorsal luxation (Figure 2). A 10 mm/min pre-load was applied to reach 10 N before starting the compression test to failure at 100 mm/min, in order to reproduce coxofemoral luxation (Flynn et al. 1994).

Figure 2: Biomechanical setup for stabilized hip with an UHMWPE implant before compression test.

2.4. Data processing

Linear stiffness was assessed by calculating the slope of the load displacement curve in its linear interval for each tensile test. Yield load was defined as the load at which the first deviation from linearity in the load displacement curve was observed visually. Failure load was defined as the maximum force measured during each test corresponding to dorsal hip luxation.

3. Results and discussion

Sample	Linear stiffness (N/mm)	Yield load (N)	Failure load (N)	Failure mode
N°1	79	185	208	CaD luxation
N°2	46	138	139	CaD luxation
N°3	60	192	192	CaD luxation
N°4	57	146	146	CrD luxation
Mean	61	165	171	
SD	14	27	34	

Table 1: Results of the four quasi-static tensile compression tests. Abbreviations: CaD, Caudodorsal; CrD, Craniodorsal

No rupture of the UHMWPE implant was observed. The biomechanical tests led to different outcomes in failure mode (Table 1). There are two possible explanations for this: (i) the universal joint pre-assembled with the distal femoral mold allowed rotation of the femoral part during the quasi-static tensile compression test; (ii) owing to the location of the UHMWPE implant after extra-articular hip joint stabilization, its placement acted as a non-return pulley in the craniodorsal direction. The femoral heads were therefore expelled out of the acetabulum during the compression tests, in the direction where the mechanical strength was the weakest, i.e. the caudal direction, thus causing caudodorsal hip joint luxation. Our stabilized hip joint results may be interpreted as the maximum load prior to the re-occurrence of hip luxation in the craniodorsal or caudodorsal direction during the immediate postoperative period. This hip joint stabilization technique can avoid reoccurrence of hip joint luxation with a compression load equivalent to up to four or five times the cat's weight. New biomechanical tests will be performed in order to validate these preliminary findings.

4. Conclusions

Extra-articular hip joint stabilization for craniodorsal hip luxation in feline cadavers, using an UHMWPE implant secured by an interference screw, produces a biomechanical failure load equivalent to four to five times mean cat weight (171 ± 34 N) prior to the re-occurrence of hip luxation. The biomechanical fixation strength of the UHMWPE implant should be suitable for extra-articular stabilization of the hip joint after craniodorsal hip luxation in cats.

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