A modified parapatellar approach for the creation of osteochondral defects in sheep

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ABSTRACT
Osteoarthritis is a problem of great social and economic importance in elderly populations, mostly in developed countries. Current treatments aim to relief the clinical signs and slow the disease development, rather than cure it.
Beyond this point, cartilage regeneration has recently received much attention from bioengineering industry, mostly because it's now that early treatments of osteochondral defects are crucial for slowing or even preventing the chronic development of osteoarthritis.
The aim of this study was to develop a modified medial parapatellar approach to the creation of osteochondral defects in sheep to further test novel biomaterials and scaffolds, with the goal of favoring early weight bearing.

Keywords: ovine, stifle joint, modified parapatellar approach, osteotomy, osteochondral defect

INTRODUCTION
Osteoarthritis (OA) is a problem of great social and economic importance in elderly populations [1], mostly in developed countries. Current treatments aim to relief the clinical signs and slow the OA development, rather than cure it. Beyond this point, cartilage regeneration has recently received much attention from bioengineering industry, mostly because it's now known that early treatments of osteochondral defects (OCD) are crucial for slowing or even preventing the chronic development of OA.
Merino sheep is frequently used as a large animal model because of its potential to support preclinical translation. The classical medial parapatellar approach to the medial condyle of the femur is unsafe due to its high risk of posterior patellar luxation and the development of secondary osteoarthritis [2].
The aim of this project was to develop a modified parapatellar approach for the creation of load-bearing osteochondral defects in the sheep's medial femoral condyle that would allow the study of the biological and biomechanical response of the osteochondral unit to biomaterials.

EXPERIMENTAL
Animal handling and surgical procedures were conducted according to European Community guidelines. Twenty-four skeletally mature female Merino sheep were divided into three groups: group A (n=8), control group, where the osteochondral defect was left empty; group B (n=8) and group C (n=8), experimental groups where a ceramic and a polymeric scaffolds were inserted, respectively.
Premedication included atropine, xilazine, butorphanol, and carprofen; induction was achieved with thiopental sodium 5% and maintenance with isoflurane 1%–2% under spontaneous ventilation. The sheep was positioned in right lateral recumbence with the left hind limb in physiologic extension fixed to the surgical table. The surgical field was prepared, and the anesthetic monitoring equipment connected.
An innovate parapatellar technique, developed previously in an *ex vivo* model, was the chosen approach. A skin incision was performed extending from the medial side of the tibial tuberosity to the immediate proximal side of the patella. At this point, the limb was temporarily hyperflexed. Subcutaneous tissue was debrided, and the medial patellar retinaculum incised to expose the joint capsule (Figure 1a). An incision was made over the joint capsule to accede the medial condyle. The incision of the oblique medial vastus muscle was prevented. With the limb in flexion, an osteochondral defect with 7 mm of depth was manually drilled in the center of the medial condyle, approximately 1.5 cm apart from the femur trochlea. This last procedure was performed under the guidance of a drill depth gauge and a drill stop to standardize the defect size (Figure 1b). The defect was then rinsed with physiologic saline and, when required, the scaffold inserted (Figure 1c). Limb extension was restored, and the joint capsule, retinaculum, subcutaneous tissues and skin were sutured, following this order.

Figure 1. Some surgical steps: a) incision of the retinaculum with the limb flexed; b) manual drill with drill stop key; c) defect in the medial condyle.

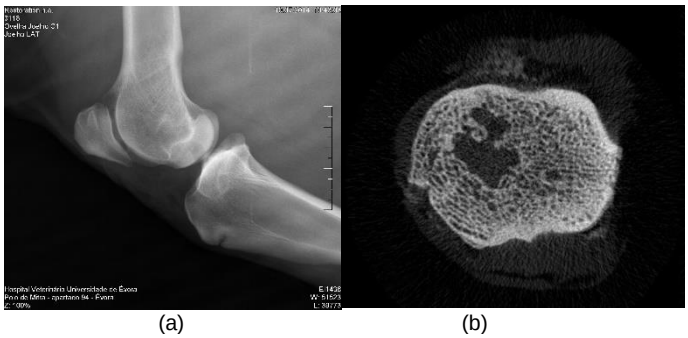
The 7-day postsurgical period was spent in a pen of the veterinary hospital. 15 days postsurgery and presacrifice two different fluorochromes (calcein green and alizarin complexone, respectively) were subcutaneously injected. During the 6-month implantation time sheep remained in pasture. After sacrifice, biological response and material integration were assessed by x-ray, micro-CT, and histologic and immunohistochemistry studies.

RESULTS AND DISCUSSION

The *in vivo* procedure was performed based on literature review and the surgeon's own experience. A minimally invasive technique, where the limb was flexed to accede the medial condyle, was developed. Thus, the disruption of the oblique medial vastus muscle, as preconized in the classical medial parapatellar approach [3], was avoided, reducing the postsurgical morbidity and the possibility of complications like the luxation of the patella and osteoarthritis [2].

All sheep recovered well and rapidly stood up after surgery, immediately supporting weight in the intervened limb; yet, in the immediate postsurgical period a lameness of grade III/IV (out of V) was patent. After the postsurgical period (8 days) all the animals were released to the pasture with no evident signs of lameness (grade I-II). *In vivo* procedures were successful with all animals completing the 6 months implantation period with obvious signs of welfare, such as an average weight increment of 6.37±4.13 kg.

Ancillary imaging, like x-ray and microCT, were crucial in offering visualization of the osteochondral defects and the biomaterial integration at the time of the surgery and after the sacrifice (Fig. 2).



(a) (b)

Figure 2. Ancillary imaging of two samples from the control group: a) immediate postsurgical plain x-ray; b) microCT cross-section image of the osteochondral defect (postmortem)

CONCLUSIONS

A new ovine model of the parapatellar approach has been developed, wherein the intra-operative flexion of the limb allows to create a condyle defect without disrupting the oblique medial vastus muscle, thus reducing postsurgical complications as recurrent patellar luxation and OA and allowing early limb loading.

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