MINIMALLY INVASIVE ANIMAL MODEL FOR IMPLANTATION IN RABBIT FEMORAL CONDYLES

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ABSTRACT

Objective: The main purpose of the present study was to create an Animal Model that would allow the evaluation of bone reaction in implants in a minimally invasive manner. Methods: In the lateral and medial condylar region of the femur in a rabbit knee, a 7 x 2.5 mm intraosseous implant was fixed with a specific guide. Results and discussion: Rabbits are well-known animals and widely used for bone reaction evaluation. Their inflammatory response (periosteal reaction) bone mineral density of long bones are comparable to those of humans. Making an Animal Model with less aggression and standardization in the implants would reward less damage to the animal and greater replicability in the researched sample. Conclusion: It was possible to format an Animal Model that proved to be simple and reproducible.

Keywords: Animal model in rabbit. Femoral condyles. Bone implants.

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INTRODUCTION

With the evolution of science and technology, especially in the field of medicine, the use of Animal Models for the evolution of techniques and treatments has become of paramount importance. Galen (129-210 A.D.), a precursor of experimental medical research with the use of animals, inspired adherents to this plan of study, but it was Claude Bernard in 1865 who launched the principles of its use in the work "Introduction to the Study of Experimental Medicine" establishing the rules and principles for it. From then on, the significance of the use of animal models gained greater attention and relevance.[1]

In orthopedics, an anatomy with greater proximity to the human is necessary, in addition to a similar pathophysiological and histological composition in order to present relevant results.[2]

Several animal test models, such as rats/mice3,4,5, rabbits3,6,7, dogs3,8,9, sheep3,10,11, goats3,12,13 and pigs3,14,15, have been developed to simulate environment and physical conditions by testing the biocompatibility of biosubstitute biomaterials for human bones "*in vivo".* In order to simulate various orthopedic situations, many defect sites were explored, such as calvaria3,16,17, femur/tibia3,18,19 and ulna3,20,21,22.

Factors must be considered to select a specific animal species as a test model. First, the animal model chosen must clearly demonstrate significant physiological and pathophysiological analogies compared to humans. Secondly, it should assess whether it is possible to operate and observe a multiplicity of study objects after surgery over a period of time23. Other selection criteria include acquisition and care costs, availability of the animal, acceptability by society, tolerance to captivity, and ease of housing24. According to the international standard, we must also consider the size of the implant test specimens, number of implants per animal, intended duration of the test, and possible differences between species when correlated with biological responses.[25]

In the present study, rabbits were preferred to be used as anatomical models for reasons discussed in this article.

A new procedure will be presented in this work that will facilitate the evaluation of biocompatibility and recovery after spongy cortical implants in Medicine and Veterinary Medicine in the specialties of Orthopedics, Traumatology, Dentistry and Neurology in a minimally invasive way.

MATERIAL AND METHODS

Study carried out at the Veterinary Surgical Center of the Mafra Campus of UNC – Fundação Universidade do Contestado (Figures 1 A and 1 B) under protocol CEUA 03/24.

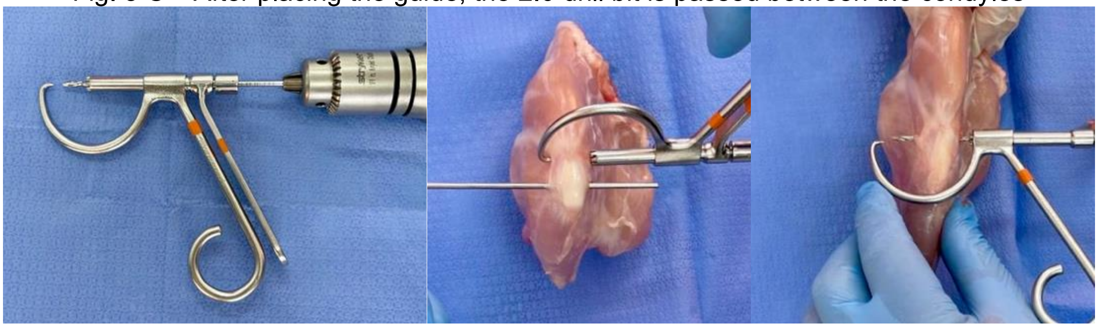
Fig. 1 A – UNC Veterinary Surgical Center (Campus Mafra - SC)
Fig. 1 B – Procedure Room with specific lighting, instrumentation and anesthesia equipment.

A piece of the left lower limb of a New Zealand rabbit with a weight of 256 grams was used. Preparation and arrangement of materials and surgical specimens (Figure 2).

Fig. 2 – Prepared materials and part

After locating the knee joint with Kirschner 2.0 wire, the lateral condyle of the femur is palpated and a 1-cm incision is made in the skin, subcutaneous and periosteum, with a 4-handle scalpel with a 23 blade. Instrumental positioning is placed on the lateral anterolateral surface and guides on the medial condyle. The first cortical is perforated, spongy until it transfixes through the medial condyle. (Figures 3 A, 3 B and 3 C)

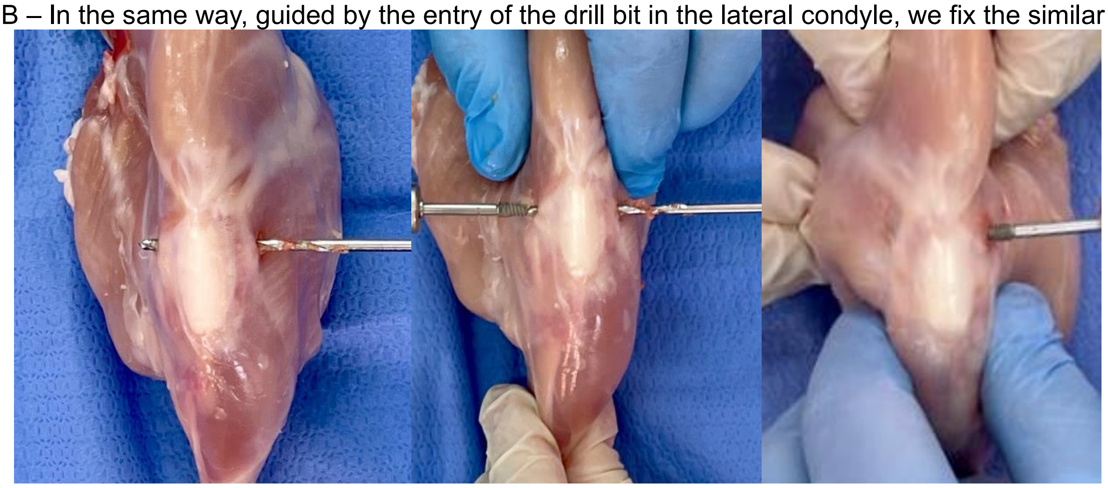
Fig. 3 A – instrument created for the passage of the drill and introduction of metal screws to allow a minimally invasive technique.
Fig. 3 B – After passing the Kirschner Wire 2.0 in the knee joint, the guide is positioned.
Fig. 3 C – After placing the guide, the 2.0 drill bit is passed between the condyles



The guide is removed and, using the orientation of the drill outlet, a 1 cm skin, subcutaneous and periosteal incision is made in the region of the medial condyle.

Visualizing the perforation of the medial condyle, we fixed the 2.5 x 7 mm screw until it aligned with the cortical surface of the femoral condyle. In the same way, following the orientation of the drill bit entry in the side condyle, we fix the other screw. (Figures 4 A, 4 B and 4 C)

Fig. 4 A – after removing the guide, the drill remains in the trans condylian position of the distal femur.
Fig. 4 B – Guided by the drill outlet in the medial condyle of the femur, we fixed the 2.5 x 7 mm threaded screw.
Fig. 4 B – In the same way, guided by the entry of the drill bit in the lateral condyle, we fix the similar screw.

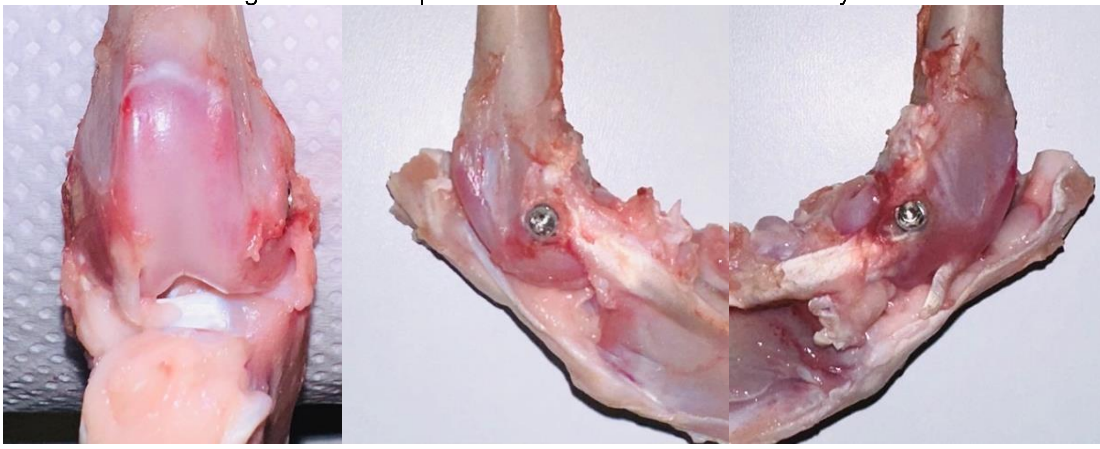


When performed in a live and anesthetized animal, after fixation of the screws, skin is sutured with single mononylon 2.0 sutures.

Duration of the procedure in a model is 5 minutes, it is estimated that in vivo after anesthetic plan and placement of drapes can last 10 to 15 minutes.

Below we see the final post-implant appearance of the metal screws (Figures 5 A, 5 B and 5 C)

Fig.5 A – Screw placements in the femoral condyles seen from the front,
Fig.5 B – Screw positions in the medial femoral condyle.
Fig.5 C – Screw positions in the lateral femoral condyle.



After the procedure, to visualize the positioning of the implants, an image study was performed in an Agfa Apolo Digital X-ray equipment with a flat panel model EVS 3643. (Figures 6 A in Posterior Antero and 6 B in Profile)

Fig. 6 A – Radiographic study in AP (Anteroposterior Posterior) of the study knee
Fig. 6 B – Radiographic study in Profile of the knee of the study

RESULTS AND DISCUSSION

A model must have sufficient characteristics to be similar to the imitated object and have sufficient ability to be manipulated without the limitations of the imitated object.

It must meet the assumptions of:

a- To allow the study of biological phenomena or animal behavior;

b- That a spontaneous or induced pathological process can be investigated;

c- That the phenomenon, in one or more aspects, is similar to the phenomenon in human beings.[26]

The rabbit is one of the most widely used animal species in musculoskeletal research, appearing in 35% of all studies reported in this area.[27,28] They are very available and easy to house and handle29,30. Costs associated with its handling and surgical facilities are less onerous than those of large animals. Their size and minimal phylogenetic development satisfy the requirements of orthopedic implant dimensions and ethical acceptability29, thus bridging the gap between rodents and large and expensive animal models for translational research.[30]

Despite the large differences in bone shape, mechanical loading, and bone microstructure, major similarities have been reported in terms of bone mineral density of rabbit long bones compared to humans.[31,32] In addition, compared to other species, such as primates or some rodents, rabbits have faster skeletal change and bone turnover.[33]

Regarding the host response, the rabbit immune system is genetically more similar to that of humans than the genes of rodents34 and the inflammatory response (periosteal reaction in long bones in rabbits are comparable to those in humans.[35]

The size of the rabbits allows the implantation of orthopedic devices similar to the human situation such as implants (pins, screws, etc...), partial arthroplasty of the joint (silicon elastomer devices) and fracture synthesis (plates and screws). Despite their adequate dimensions, multiple, bulky implants are clearly limited, requiring rabbits weighing more than 3 kg or larger species, with the exception of femoral condyles, which can receive multiple small-sized implants or wide cylindrical implants.[These] characteristics make rabbits the first choice when researchers develop an animal model for the *in vivo* testing of a new bone substitute biomaterial.[37]

Among several advantages over other species they reach sexual and skeletal maturity around 5-6 months of age, thus allowing easy and fast reproduction and providing a mature bone structure for orthopedic purposes. Males are used more often because they grow faster than females and reach larger dimensions. (Males gain 1 and 0.7 mm in femoral and tibial length, respectively, every 2 weeks of age, compared to 0.2 and 0.4 mm for females).[38]

Both genetic standardization and the large number of individuals available for research purposes make the rabbit useful for multiple investigations. To meet the above-mentioned requirements, the New Zealand rabbit is the most suitable strain in orthopaedic research, and has been reported to be used in 99% of the studies.[39.40]

CONCLUSION

The present animal model in rabbits allows the technique to be formatted for simple spongy cortical implants. Being reproducible and minimally invasive, it may contribute to studies of the physiological interaction of implants in bone tissue.

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