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# DIFFERENT ANIMAL MODELS OF BONE DISTRACTION

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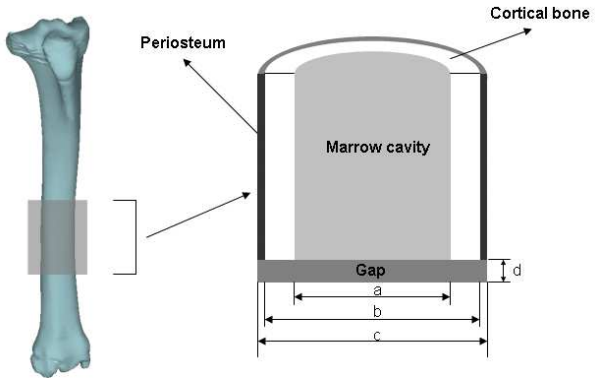
## ABSTRACT

Distraction osteogenesis is a surgical technique that produces large volumes of new bone by the gradual separation of two osteotomized bone segments. Many animal species have been used as experimental models to study limb lengthening but no computational simulation has yet been performed to report comparisons between different geometrical models. Therefore, the aim of this work is to analyze numerically the differences in tissue patterns and gap stiffness (directly related with reaction forces) for various animal species, based on their size and other characteristics. Animal models chosen are: rabbit, sheep and human. The simulations are performed in the diaphysis of the tibia which is assumed to be cylindrical (Figure 1 a). The parameters required are the diameter of the diaphysis, width of the periosteum and bone marrow and size of the osteotomy gap (Figure 1 b).




(a)

| Dimensions (mm) | Sheep | Rabbit | Human |
|---|---|---|---|
| a | 12 | 4.52 | 14 |
| b | 20 | 8.02 | 28 |
| c | 21 | 8.82 | 30 |
| d | 0.5 | 0.375 | 1 |

(b)

Figure 1: a) Scheme of the geometry of the animal models; b) Geometrical values for each animal model

A model previously developed for fracture healing has been used to compute tissue distribution in the distracted gap [1] with the inclusion of the maturation state of the cell *($m_i$)*. This additional state variable was included in the model to consider the effect of the load history. It is biologically plausible to assume

that cells will differentiate only if they have been subjected to a specific mechanical environment for a period of time.

Moreover, we assume that the differences between large animals (sheep and human) and smaller ones (rabbit) is only geometrical and temporal and not in the biology of limb lengthening. Consequently, the length scale was adapted for each animal specie and all temporal parameters of the rabbit were scaled by 2 to represent the faster progression of tissue development in the rabbit than in the sheep and human [2].

In order to analyze the ability of the model to reproduce the main temporal and spatial differences of these three case studies, reaction forces as well as tissue distribution have been computed and compared with experimental findings [3-5]. For instance, day 9 after the beginning of distraction, tissue outcome varies significantly. In the rabbit, cartilage has already formed whereas in human and sheep the gap is filled mainly by granulation tissue (Figure 2). Thus varying the geometry of the model affects to the differentiation processes by altering the maturation state of the cells within the distraction gap.

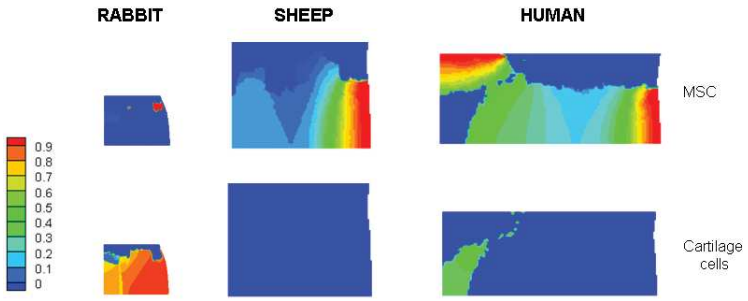



Figure 2: Tissue distribution day 9 after the beginning of distraction for the three animals analyzed.

To the authors' knowledge, no computational study has been carried out to compare the main differences in the mechanical environment for different animal models. This model is able to predict successfully the reaction force as well as tissue distribution for the most popular experimental models used in distraction osteogenesis. Moreover in this study it is shown that the mechanical environment for both the sheep and humans is very similar leading to reaction forces of the same order of magnitude.

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