MODELLING THE INITIAL CALLUS PHASE IN BONE FRACTURES

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1. Introduction

Bone healing is the process of a fracture in which the reconstruction and continuity of the fractured bone occurs.[1]. This process can be divided in the succession of six fracture healing phases: the acute inflammatory response, recruitment of mesenchymal stem cells (MSCs), generation of a cartilaginous and a periosteal bony callus, revascularization and neoangiogenesis at the fracture site, mineralization and resorption of the cartilaginous callus and bone remodelling. [2]

From these six processes, this paper focuses on the initial callus phase that happens during the third stage of the bone healing process. This phase is essential to obtain the initial geometry of the callus, that is needed for the development of subsequent consolidation phases. The proposed algorithm can be applied to 2D and 3D geometries, allowing the simulation of a finite element model to obtain information that otherwise is difficult to obtain. In this case, the information obtained is the volume of callus generated per day.

2. Materials and Methods

The growth algorithm for the initial callus phase depends on several interconnected phases. Each one of these phases has a different mission: calculation, topology, control and evolution [3].

The calculation phase consists of a finite element module that solves a diffusion problem for specific initial and boundary conditions.

For its part, in the topology phase, the algorithm: recognizes the surface, how it looks like and indicates how the callus will grow.

The growth rate check takes place during the control phase. In this phase, the growing speed can be modified according to the presence of different molecules in the blood.

Finally, in the evolution phase, the algorithm causes mesh growth where previously indicated.

3. Results

As a result of the application of this algorithm, different callus volume values have been obtained for different moments of callus closure for a transverse diaphyseal fracture of the femur. A transverse fracture is a horizontal fracture and the study case is made with a transverse six mm gap fracture:

Day	0	12	24	36	48
ΔVol (mm^3)	0	3080	7008	9166	10279

Table 1: Callus volume increment for different days.

4. Conclusions

The algorithm for the initial callus phase allows the development of a tool that helps in the process to obtain information, generally difficult to access. This algorithm works with four well differentiated phases and it works for 2D and 3D.

5. References

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