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Fracture pattern projection on 3D bone models as support for bone fracture simulations

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ABSTRACT

Background and objective: Obtaining bone models that represent certain types of fractures is limited by the need for such fractures to occur in real life and to be processed from medical images. This work aims to propose a method that starts from the design of specific fracture patterns in order to be projected on 3D geometric bone models, being prepared for their subsequent geometric fracturing.

Methods: The process of projecting expert-generated fracture patterns has been approached in such a way that they contain geometrical and topological information for the subsequent fracture of the triangle mesh representing the bone model, giving information about the validity of the fracture pattern due to the design process, the validation performed, and the relationships between the fracture lines.

Results: Different 3D models of long bones have been used (femur, humerus, ulna and fibula). Also, different types of fracture patterns have been created. These patterns have been used to obtain their projection on three-dimensional bones. In this study, an expert validation of the fracture patterns projected on the bone models is performed. A forensic validation of the fracture patterns used as starting point for the projection is also performed for cases in which this fracture is produced by impact, for which there is scientific evidence based on forensic analysis. This validation also supports the experts, giving them the necessary feedback to complete or modify their fracture patterns according to criteria analyzed from a forensic point of view.

Conclusions: The patterns fit the bone models correctly, despite the irregularities of the bone models, and correspond to the expected projection. In addition, it provides us with a clear line of work, by using the topological information of the fracture pattern and the bone model, which allows us to establish a consistent basis for future guided fractures.

1. Introduction

The difficulty in obtaining bone models as well as the access to clinical images of fractured bone models, is due to the insufficient collection and storage of information on bone fracture patterns. A preliminary step in the solution to the existing problem concerning the limited availability of three-dimensional bone models that represent fractured bones is proposed in this work.

This article presents a procedure for the projection of a fracture pattern represented in two dimensions on a three-dimensional representation of a healthy bone model (Fig. 1). The aim of this procedure is to simulate the representation of a real and valid bone fracture pattern in a virtual bone model. Through the representation of the two dimensional real fracture pattern on the three dimensional bone model we can project the fracture lines to obtain a model of the fractured bone with realistic morphological characteristics.

As a starting point, a fracture pattern generated in 2D will be used through a tool specifically designed for this purpose [1], in which the experts prepare a specific fracture pattern. This fracture pattern is projected on the bone model in order to preserve geometric and topological information of the fracture pattern for its possible validation. It could also be used in a possible decomposition of the 3D model into different fragments according to the designed fracture pattern.

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