Mini Review

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Biomodeling and numerical analysis of upper limb under the effect of bending loads in forearm

Abstract

The study of biological systems today by the application of numerical simulations allows to obtaining analysis of structural mechanical behavior in components of the entire human body. In this research work it is presented the mechanical behavior of radio and ulna bones from the biomodeling of their tissues and how they react under the effect of bending loads. The biomodel developed consists in two kind of material (bones tissues trabecular and cortical) and contact consideration between bones are taking into consideration. This kind of biological system is very difficult to simulated, because the kind of assembly that it has. Nevertheless, results tend to reproduce the manner the system performs.

Keywords: bone tissue, radius, unla, biomodeling, numerical analysis

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Introduction

Currently the ability to understand the mechanical behavior of the various components of the human body is in a process of continuous improvement. This is why a methodology for establishing the steps of the biomodeling of cortical and trabecular tissues from tomography to the construction of a solid for analysis with the finite element method and the interpretation of the results obtained to understand the behavior of each bone tissue separately.[1] The construction of a bone model begins from filling areas in tomography using the Scan IP® program (Figure 1) which can recognize DICOM formats to generate a point cloud which will be transformed into an STL format (Figure 2) to be recognized by the Power Shape computational system® and thus begin to build a shell for export in ANSYS® and perform the corresponding numerical analyses.[2]

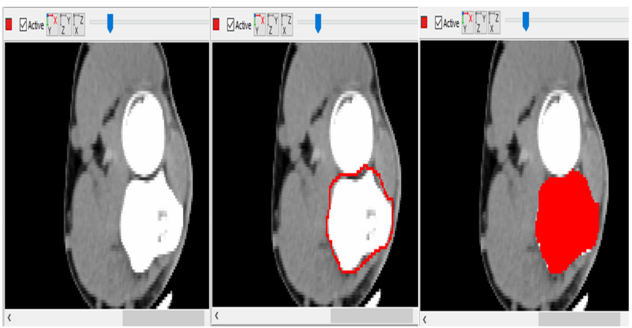

Figure 1 Area delimitation in cortical tissue.

Methodology

Numerical analysis of models developed in the cortical and trabecular tissues of both bones is obtained as follows:

A. Definition of the type of analysis.

B. Set the geometry type.

C. Finite element type selection for discretizing generation.

D. Set the border conditions for the application of the external agent.

E. Model solution.

F. Getting results.

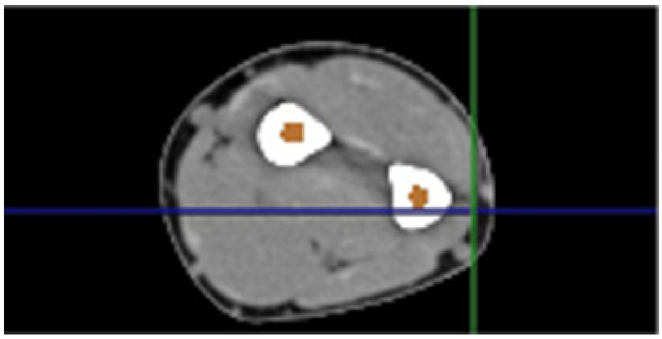

Figure 2 Area delimitation in trabecular tissue.

Considering that this type of analysis is a solid, the command 8 node 133 is used so it is called that it is high order.[3] This provides the ability to generate more nodes for more accurate analysis. On the other hand, when the discretization of the bones is established it is automatically generated by the program by the irregularities of the surface of the bone tissues (Figure 3).[4] To solve this type of analysis itestablishes an analogy between the human body and a machine composed of pulleys and levers. Where a 196.2 N load is considered on the X axis in the distal zone. Based on the characteristics of an individual in Mexico is 74kg, assuming that the position is held statically and that the angle formed between the arm and the elbow is 90°.

Figure 3 The surface of the bone tissues.

The border conditions for this analysis are established at the contact points of the radius and ulna in the elbow joint in which all degrees of freedom are restricted on the X, Y and Z axes. It is important to establish that the system works as a recessed beam, modifying only the way the external agent interacts with the bones (Figure 4).[5] The application of the spot load for bending analysis is placed in the distal epiphysis of the radius because it is displayed as a lever as it is one of the most common forearm service conditions because it is used to lift or hold objects (Figure 5).[6] The model solution allows to visualize the values of the maximum and minimum stresses during the support of the point load of the cortical tissue (Figure 6).[7] In the same way in the trabecular tissue (Figure 7) when they are subjected to flexion.[8]

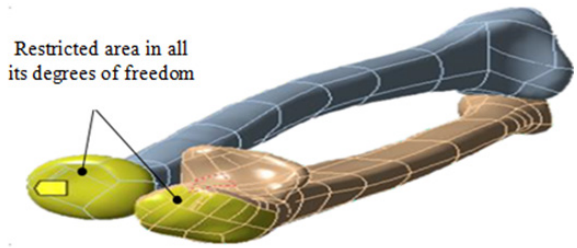

Figure 4 Applying border conditions.

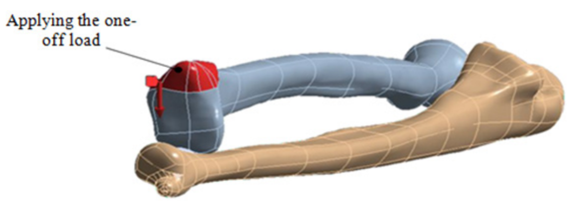

Figure 5 Loading application on the model.

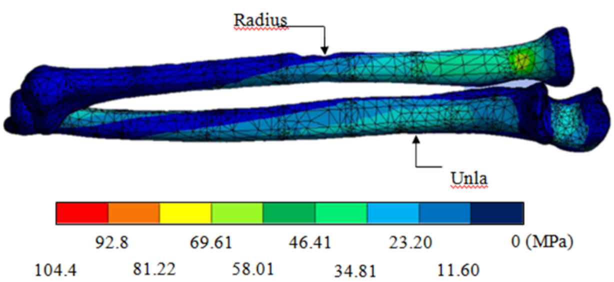

Figure 6 Von Mises effort of cortical bone.

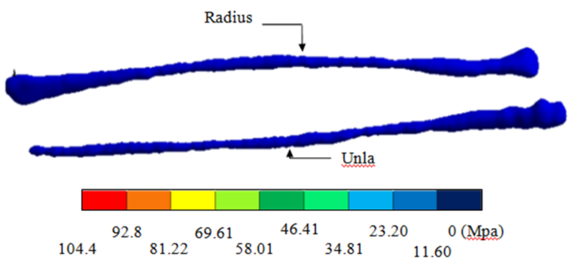

Figure 7 Von Mises effort of cortical bone.

Discussion

Forearm modeling and analysis is a very helpful tool because it not only works to understand the behavior of bone tissues, but in the medical area it is important to avoid future conditions in this upper limb section and obtain new tools for modeling biological systems.

Conclusion

With the methodology presented in this work it is possible to carry out the construction of a biological model of forearm from a computerized axial tomography, in this way a series of virtual objects that share characteristics are similar to those of the real bones. On the other hand, with this type of work it is possible to visualize the actual behavior of the radio and ulna bones when they are subjected to point loads during the action of lifting or holding an object. Obtaining results using Von Mises failure theory it is possible to visualize a cortical tissue stress of 104.4 MPa presenting itself in the proximal area of the radius and for trabecular tissue an effort of 23.20 MPa is observed that is distributed along its longitudinal axis. This in turn indicates that the bone being a ductile material has linearity, continuity, homogeneity and isotropy.

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None.

Conflicts of interest

The authors declare, that there is no conflict of interest.

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