A NEW MODEL TO STUDY MICROMECHANICS OF FRACTURE IN CORTICAL BONE

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INTRODUCTION

Propagation and elongation of micro cracks is known to be one of the main reasons of encountering fracture in cortical bones [1]. The difference between the result of experimental studies on bone and accepted rules about conventional materials emphasizes that special attention must be paid to other factors while dealing with mechanic of bone fracture [2]. In accordance with experimental data, heterogeneous microstructure of bone which is due to its inclusion of osteons and Haversian canals has influential effects on both propagation and blocking of cracks [3].

A successful research on micromechanics of human cortical bone, based on linear elastic fracture mechanics theory was done by Guo et al [3]. On that research a 2D finite plane strain model containing one circular discontinuity and a single micro crack was studied, by applying force on the boundary of a finite domain [3]. Later Arshi and Raeisi specified the influence of micro cracks on stress concentration factor by inserting extra micro cracks into Guo's model [4].

METHODS

By considering only one osteon in a finite domain, deduced model would severely deviate from real bone structure behavior. Therefore a new model for analyzing fracture in cortical bone should be presented. Our new model is assumed to be an infinite plane, since in bone, mechanical forces are applied in macro structure level while our region of interest is in micro bone scale.

Current model is an infinite plane with elastic properties defined as λ and μ (Lamé coefficients) which contains four circular discontinuities having dissimilar elastic properties from the plane and a micro crack which is positioned between them. Moreover it is assumed that both plane and discontinuities are of linear elastic isotropic materials where the boundary between these two continua is perfectly bounded to avoid relative displacement between mating nodes. In addition Forces are applied in infinity.

Based on Betti's reciprocal theory and Kelvin fundamental solution, boundary element method is implemented to solve the problem. After calculation of displacements and tractions on the boundary of discontinuities, it is possible to specify stress and displacement inside the domain. Finally stress concentration factor on the tip of cracks is determined and crack propagation in cortical bone could be monitored.

RESULTS AND DISCUSSION

Results show that under tensile loading, crack propagation is highly affected by the distance between osteons. In the case where the gap between the osteons is smaller than a specific amount, crack would not be able to penetrate the space between them. A schematic primary micro crack and its path of propagation near osteons and Haversian canals are illustrated in figure 1.

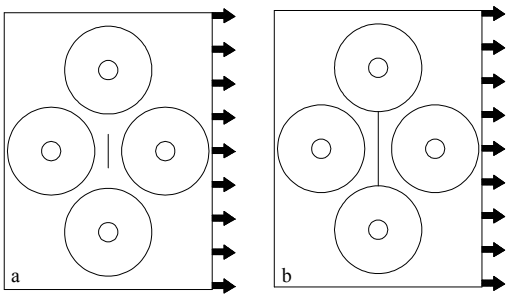

Figure 1: Propagation of a micro crack under tensile loading (a) primary micro crack (b) Path of crack propagation

CONCLUSIONS

Considering four osteons instead of one and analyzing an infinite boundary by means of boundary element method which enables us to apply forces in infinity, assure that our model describes fracture in cortical bone better than previous ones.

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