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A MODEL TO PREDICT THE EVOLUTION WITH TIME, OF ORTHODONTIC TOOTH MOVEMENT

***Lídia Carvalho[1], Mildred Ballin Hecke[2], Gil A-Campos[1], José Simões[1]**

[1] Department of Mechanical Engineering, University of Aveiro - Portugal
lcarvalho@mec.ua.pt

[2] PPGMNE/CESEC-Civil Eng Research Center, Federal University of Paraná, P.B.19011, 81531-980, Curitiba, Paraná, Brazi
mildred@ufpr.br
www.cesec.ufpr.br/bioengenharia

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ABSTRACT

The orthodontic treatment is largely used in clinical practice in our days. The clear understanding of all the biological phenomena involved in tooth mobility, as a consequence of the orthodontic treatment and functional load, is necessary to achieve equilibrium in the stomatognatic system. In overall this biological process of adaptation there are several intervenient like teeth and alveolar bone but the periodontal ligament (PDL) plays an important key role. It is considered that bone remodelling process involves a mirostructural adaptation [5] and can be model using a mathematical formulation, based in the theory of thermodynanics with internal variables [1,7], is being used in the constitutive modeling of PDL. The internal variables are associated with both local loss and gain of stiffness. According to experimental results, strains in bone during physiological activities, related to orthodontic load, are very small. In that case the Helmholtz free energy can be assumed as a function of elastic strain tensor and internal variables. The Helmholtz free energy may consist of two parts: one mainly related to elastic strain but affected by loss and gain of stiffness, and other is the energy exclusively related to them. The state laws define the "forces" associated with the state variables (stresses and thermodynamical forces). A dissipation potential related to entropy production rate is expressed in terms of this loss and gain of strength conjugate forces [4,6].

The PDL can be assumed as been composed of two parts, one considered isotropic, that is composed by a matrix of connective tissue and another part, considered anisotropic that is composed by collagen fibres [2]. In this way, the behaviour of the PDL is time depending and also depends on the velocity rate of applied load. The proper choice of the mechanical properties and the constitutive model used to describe the response of the PDL such as the surrounding bone media, are important in dental mobility, and because it can gives the strain patterns inside the PDL, which are important to evaluate and identify the regions of remodelling processes in surrounding bone media.

Within this work is adopted a hyper-elastic and anisotropic model, to describe the PDL, used by others authors and presented in literature. This approach uses the theory of continuum and is based in large deformations. The evolution in time is performed by considering time steps, in equal intervals. Also, the model includes a vector which represents the preferential directions of the collagen fibres of PDL. According experimental results, strains in bone after application of an orthodontic load are very small and the bone present microdamage and microcracks that might be removed by remodelling process. A variational approach [3] using internal scalar variables to describe both local loss and gain of stiffness is used to describe the constitutive model of alveolar bone surrounding the tooth. A Finite Element Method is applied to a 2D model of a tooth, LPD and bone model. The results are compared to a traditional linear elastic model.

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