ANALYSIS OF THE HUMAN MASTICATORY DYNAMICS

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Introduction

The morphology of the human masticatory system is of a complex nature. The mandible, unlike any other bone in the human body, is slung between two almost symmetric joints named temporomandibular joints (TMJ). The mastication process can be divided into 3 main stages: opening, closing and power. In this work, the three stages are simulated by means of finite element analysis which allows the study of the stress distribution produced in the mandible and joint during the complete process.

Methods

A 3D finite element model of the mandible was created including the TMJs. The mandible bone behaviour was simulated using an anisotropic bone remodelling model, previously used in [Reina, 2007]. The articular disc of the TMJ was assumed as a quasi-linear viscoelastic material [Fung] with properties obtained in experimental tests and the ligaments of the joint were simulated with a fibre-reinforced hyperelastic model [Gardiner, 2003].

Masticatory muscles forces were applied as external forces, distributed over the insertion area of each muscle. Right molar chewing was simulated by restraining the movement of the upper surface of the right molar.

Results

The maximum and minimum principal stresses were estimated along a complete chewing cycle. It was found that the stresses were higher at the instant of centric occlusion. As can be seen in fig.1, the intermediate zone of the disc was subjected to the highest compressive stresses. It was also noticed that the stresses in the contralateral disc are higher than in the ipsilateral one.

To determine the influence of repeated cycles and due to the viscoelastic nature of the articular disc, the first closing stage was simulated again after the opening stage. The stress distribution obtained in the first cycle in the mandible and in the TMJ discs were compared to those of the second cycle, but no significant changes were noticed.

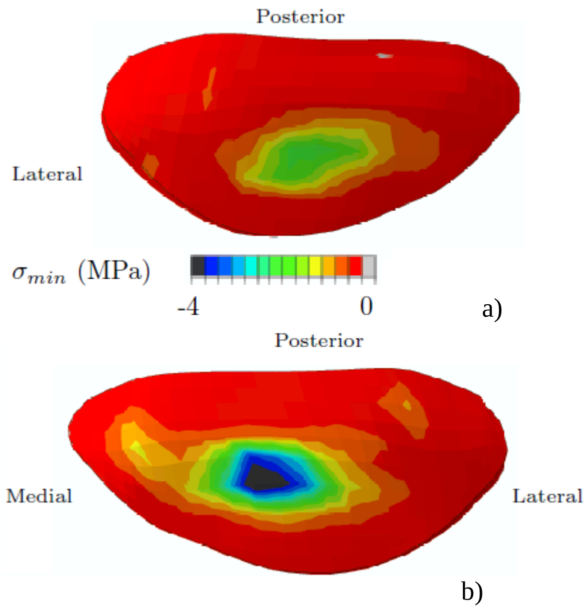

Figure 1: Distribution of the minimum principal stresses in the articular discs, a) at the ipsilateral (working side) and b) at the contralateral (non-working side).

Discussion

From the simulation of the chewing cycle, it can be concluded that the highest stresses in the mandible and in the articular disc take place during occlusion, when the maximum activation of the elevators muscles is applied. During opening, the maximum stresses were observed at the instant of maximum opening and located at the rami and chin. However, the stresses were much lower than those obtained during closing. Instead, the ligaments of the joint, suffered the highest stresses during opening, as expected. The main function of these components is to limit the movement of the joint and that is why they are mainly active when the mouth is opening.

References

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