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STUDY ON THE TENSION STATES OF THE MANDIBLE BY APPLYING THE FINITE ELEMENTS METHOD

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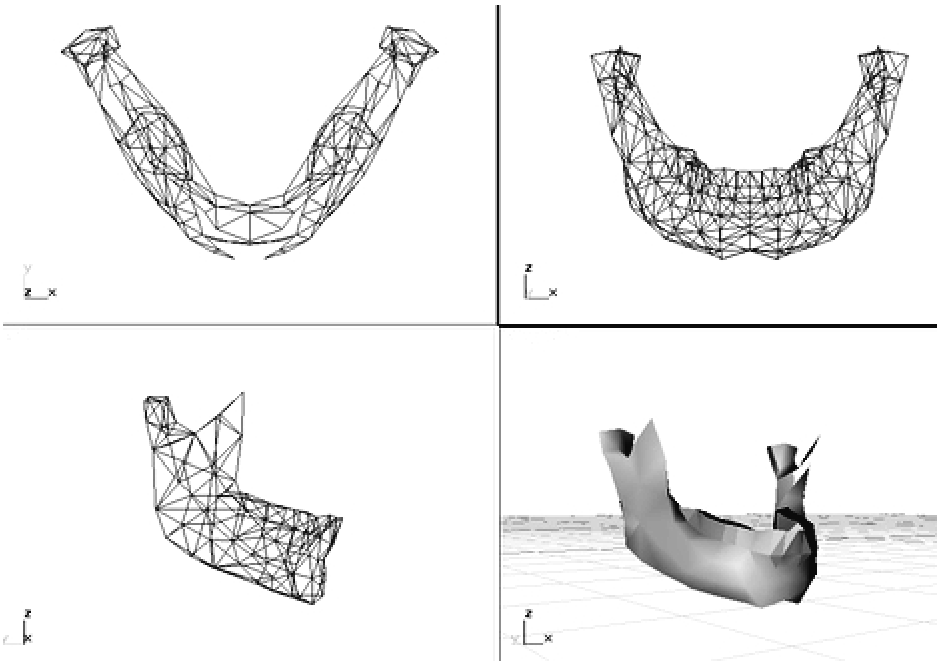
Abstract
This study implies the complex interaction between the active and passive muscular forces transmitted to the structure while closing the mandible. It has been accepted that the ligaments of the articulations play a major role in condilian transmitting while these movements, but it has been ascertained that they are not directly involved in transmitting the force through articulations. Because of that, it was believed that muscular forces and the muscular restraints caused by the articular movements need a sufficient and necessary condition to produce ordinary movements of closing the mandible.

1. Introduction
Following the basic rules of shaping, simulating and computer based designing, a three-dimensional model of the dental mandible was created for studying and analysing the mechanical stress. The discretic structure of the mandible, seen from the sagital plane, is the one in picture 1.1 the number of the finite elements created by discreting the structure to analyze, being chosen depending on the size of the studied object.

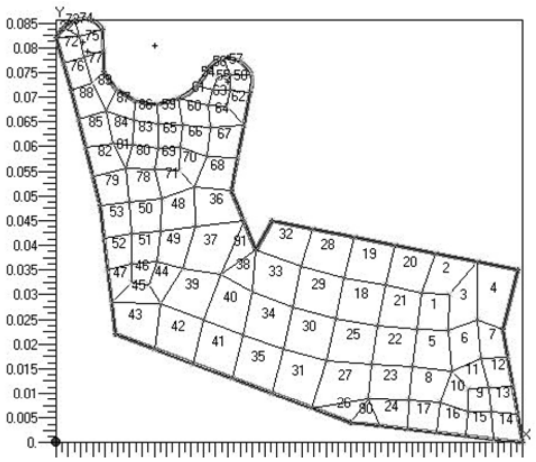
2. The method of finite elements
It was considered that the bone of the mandible has a homogenous structure, by its architecture, the bone is adapted to the function of resistance to the pressure and mechanical traction and it is the subject to the principle “with little material, maximum of resistance”.

The masseter muscle is the strongest muscle that operates on the mandible, meaning that it emits the biggest force and the biggest mechanical work both alone and together with the pterygoid muscle. In a first studied case, it was considered that only these two muscles operate on the mandible, ignoring the temporal muscle which operates a lower force. It was taken into account the normal figures emitted in the mastication process and not the extreme ones because the map of the stress on the mandible bone is the same (1.2). The area of maximum stress was marked with an arrow, which is between the mandible condile and the coronoid process. A second critical area, with figures close to the first one, is also the one from the internal angle of the mandible, right after the last molar (elements 31 and 32), a normal thing taking into consideration the typical shape of a stress concentrator which this area has.

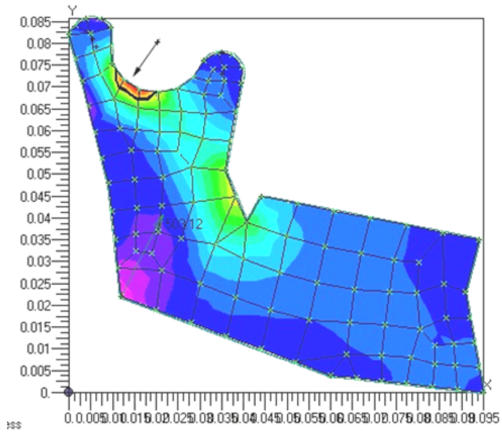
It is noticed that, under the action of the masseter muscle, whose point of insertion is on the turn of the mandible and acts when pulled up under 60-70° angle, with an average total force of 500 N, maximum tensions are produced in the points shown by the arrows. These areas match on the real mandible with the bony wall of minimal thickness.



1.1-3D model of the dental mandible, created for finite elements analysis method



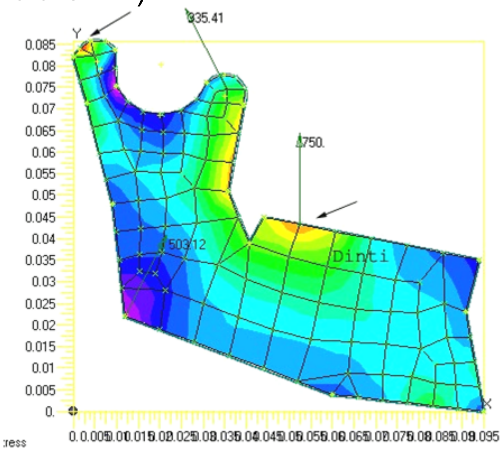
1.2-the discretized structure of the mandible seen in sagittal plane



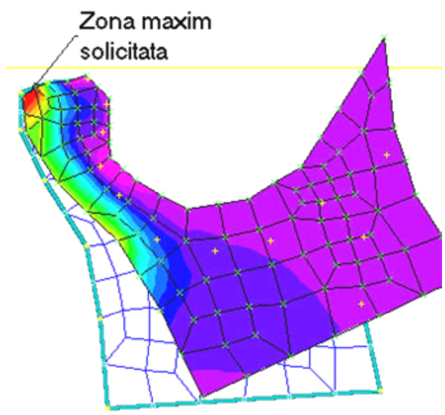
1.3-the distribution of the efforts under in the mandible under the action of the masseter and pterygoid muscle

In picture 1.3, the action of the temporal muscle was taken into consideration. This is the closest to reality state of affairs because only the action of these muscles counts as share. It can be noticed that the maximum tension exerts over the first and second molar, depending on the way of obtaining the occlusion. A very big stress is also taken by the temporo-mandibular articulation. The temporo-mandibular articulation is very flexible, more flexible than the system created by the touching molars. The teeth surface is even more sensible and reacts instantly at pain. It is a reflex action of self defending of the organism, because it was demonstrated that all these actions have a cerebral co-ordination and consequently a *feedback* comes up.

As a practical conclusion, the temporo-mandibular articulation will never be dangerously stressed during mastication, because while occlusion, the teeth act like a restrictive filter. A case when the temporo-mandibular articulation suffers is not when closing the mouth and biting, but when exaggeratedly opening the mouth, when the mandible condils can come out of the glenoid cavity, their natural slots. Dislocated from the articulation, the mandible is stuck in the new position (abnormal and extremely painful) by the sudden contraction of the masseter muscle and can be put back in its place only by surgery; this consists in reversing the stages of the “accident”, that means pushing it back in the articulation, in its normal position. To define more accurately the stresses from the temporo-mandibular articulation, the mandible condil was discretized, being studied its behavior. (picture 1.4)



1.4- the distribution of efforts in the mandible under the action of the masseter, pterygoid muscle and the temporal



1.5- stresses in the temporo-mandibular articulation

The geometry of this region underlines what optimum structure of resistance was created here. We can draw the following conclusions:

- the most stressed areas from the bone section are in the molar region on which it is made the dental contact
- these areas are directed in the action line of the mastication muscles
- the geometry of this maximum stressed area is adapted to the effort it has to endure, being the most evolved one from the studied section
- left side stress of the mandible does not match identically to the right side because of the general asymmetry of the human body

During the normal functioning, the contact from the molar area can be considered as equivalent with the closed mandible. Therefore, the influence of the dental arc was simplified by designing the occlusion points only in the molar area. The temporal muscles movements are modified. Because of the incisors missing from the model the mandible’s incisors reach in the superior stage in front of the superior alveolar arc.

The muscular forces applied in this study are relatively small as compared to the inner power of some mastication muscles. The magnitude was applied because it can be exerted even by the smallest muscular parts (the upper part of the lateral pterygoidian muscle). The movements of the mandible begin and stop rapidly. This is opposite to the natural movements which are slower. There were shaped muscular forces as level of response to the constant magnitude. In reality, the activating levels of the muscles are not constant and their productive forces are largely influenced by the change of the movement’s velocity. Furthermore, the natural closing movements of the mandible are not controlled by a single pair of mastication muscles but a combination of muscles. It was shown that the synchronizing differences in the muscle contractility are very important in obtaining some slow movements. Including these properties in the model will certainly lead to more realistic movements but it will considerably hide the contributions of the different mastication muscles to closing the mandible.

The models including the skeleton muscles can simulate the viscosity as a passive muscular property. The figure of the friction affects only the speed but not the mandible movement line. This parameter is not necessarily isotopic and linear, so it can have greater effects over the relation between the muscular forces and the mandibular movements, provided by this model.

This synchronizing mandibular closing movements for the masseter and pterygoidian muscle was reasonable. It was demonstrated however that it is irrespective of the figure of mandibular friction. Furthermore, the movements will be faster if the muscular forces increase. The mentioned time levels are considered cautious and they must be qualitatively interpreted.

Conclusions

This study implies the complex interaction between the active and passive muscular forces transmitted to the structure while closing the mandible. It has been accepted that the ligaments of the articulations play a major role in condilian transmitting while these movements. While these ligaments allow a high rate of movements it has been ascertained that they are not directly involved in transmitting the force through articulations. Therefore it was believed that the muscular forces and the movement restraints caused by articulating surfaces need a sufficient and necessary condition to generate usual mandible closing analyses. A dynamic mathematic model of six degree freedom of the human mastication system has been operated for qualitative analyses of the various mastication muscles involved in this type of mandibular movements. In closing simulating movements it was discovered that the usual noticed movement, that includes a condilian movement of swinging-somersaulting along the articulating surface, can be generated by different separated pairs of mastication muscles, from which some parts of the masseter muscle seem to be the most appropriate to do this movement.

The results can be, however, explained by biomechanical analyses which include not only muscle and the articulation forces as it used in anatomic standards tests, but also the directions generated by these forces.

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