BIOMECHANICAL BEHAVIOUR OF ORO-MAXILLOFACIAL PROSTHESES (MATHEMATICAL MODELING IN ORO-MAXILLOFACIAL SPHERE)

AGNES-MIHAELA CRĂCIUN, MAGDA-ECATERINA ANTOHE and NORINA CONSUELA FORNA

"Gr.T. Popa" University of Medicine and Pharmacy Iasi, Romania
Faculty of Dental Medicine
Discipline of Clinics and Therapy of Partial Extended Edentation

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The tumor pathology resulted in substance losses and the traumas at facial level are only several aspects that mark patients in a mutilating way, modifying significantly and sometimes irreversibly their behavior, turning them from active, social people into isolated ones. A prosthesis and so much the more an obturator shall not be worn unless they remake the lost functions and are accepted by the sick person from the psychic viewpoint. The final goal of treatment follows the improvement of sick person's life quality and represents a psychological support both for them and their family. The losses of intra-oral substance are solved in the clinical register by means of augmentation biomaterials of the Bio Oss type. As for the losses of extra-oral substance, they are solved following the mathematical modeling by applying simple pressure at the prosthesis level or by fixing the prosthesis with four magnets that were attached beforehand to the bone. The substance losses represent a complex pathology, the contribution of the filling materials, the prosthetic means correlated to the particularity of the clinical case are essential for a successful clinical finality. We may not speak of a successful prosthetic implant if we do not pay a special attention to the mucous-bony deficit by specific prosthetic techniques.

Key words: Loss of substances; Epithesis; Trauma; Biocompatibility.

INTRODUCTION

The substance losses in the oro-maxillofacial domain represent a complex clinical entity with a deep impact on the patient's general state and their social insertion turning them into a person condemned to isolation.

The causes leading to substance losses are represented most of the time by traumas, post-tumor ablations or maxillo-labio-facial clefts.

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In recent years, major progress has been made allowing in the near future the creation of maxillofacial prostheses very similar to the natural structures and that may resist longer [3].

The therapeutic approach is complex uniting most of the time surgical reconstructions with epitheses, those prosthetic substitutes completing the substance loss and giving again naturalness to the mutilated face.

The rehabilitation of the substance losses has an ascendant way starting from intra-orally limited defects up to aspects having a crescendo character with the perturbation of the functions of the stomatognathic system without eluding two well delimited forms, namely the mutilating resorbtion

and atrophy processes triggering serious facial modifications and the absence of a significant bony capital caused by the tumor ablation.

PURPOSE

This study focuses on the identification of the ways of oral rehabilitation in the oro-maxillofacial territory depending on the particularity of the clinical case and the etiology of the substance losses.

The scientific activity unfolded abides by the objectives provided in the initial plan aiming at finishing the mathematical modeling in full compliance with the real clinical situations of a group of patients diagnosed with substance losses, of different sizes anchored in the intra or oral territory, their solving and the biomaterials involved being different.

At the same time, this stage is dedicated to the clinical applications, both silicone biomaterials and the situations modeled by the finite element method.

MATERIAL AND METHOD

Intra-oral substance losses

For the three-dimensional reconstruction of different types of intra and extra-oral maxillofacial substance losses we used the universal programme Amira for 3D reconstructions for any type of Computer Tomograph.

We made a 3D simulation in real time of the flexible mandibular prosthesis to notice the dispersion of the forces exercised on the entire surface of the toothless prosthetic field from the patient's oral cavity under the action of the masticatory forces and the quantification of the tensions at the mucous-bony level.

Based on displacements, we determine the tensions at the basis of the partially acrylic flexible prosthesis and the tensions at the level of the mucous-bony support that reflect in the dynamics of the resorbtion and atrophy process.

Extra-oral substance losses

The next case brings us to the territory of maxillofacial prostheses. The patient has a serious substance loss with the affectation of the orbital area, the nasal area also spreading in the zygomatic and chin regions. In patient's first CT, we scanned and made the analysis by finite element of the clinical case.

This type of modeling intends to highlight the distribution of tensions from the level of bone for two cases:

– simple sustaining of the maxillofacial prosthesis

– fixing the maxillofacial prosthesis by four magnets.

We start from a skull having no bony mass defect. Subsequently, virtually we extract the bony mass that was really removed surgically (Fig. 1).

RESULTS AND DISCUSSIONS

Mathematical modeling and clinical applications for the intra-oral substance losses

The dispersion of forces at the level of the mucous-bony support is fully linked to the masticatory force generated by the natural dentition, by diverse types of fixed restorations as well as by the mobile prostheses inducing low tensions at the level of the anatogonistic arch, the presence of the silicon material proposed by us as lining material for these types of prostheses after the finishing of the adhesion mechanism between the two biomaterials being in full compliance with the biomechanical principle of reducing pressures at the mucous-bony level. A high frequency of the analyzed cases is represented by substance losses at the mandibular level, the analysis by finite element revealing tension concentrators at the level of the edges of substance defect (Fig. 3).

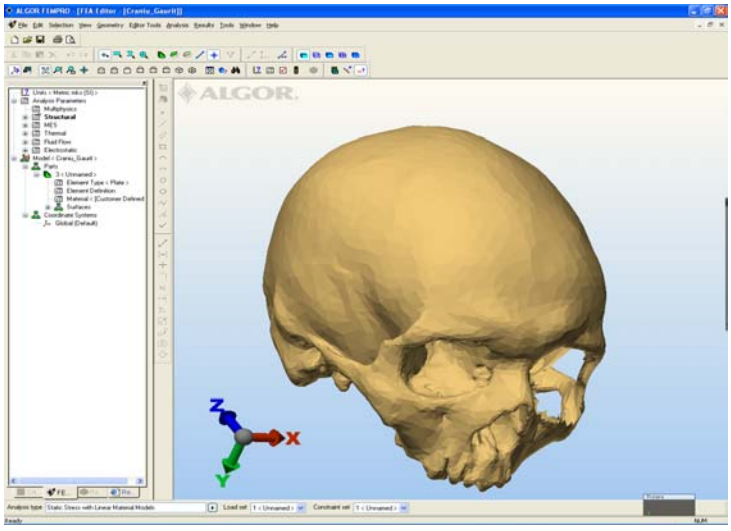

Fig. 1. The skull from which they virtually removed the bony mass.

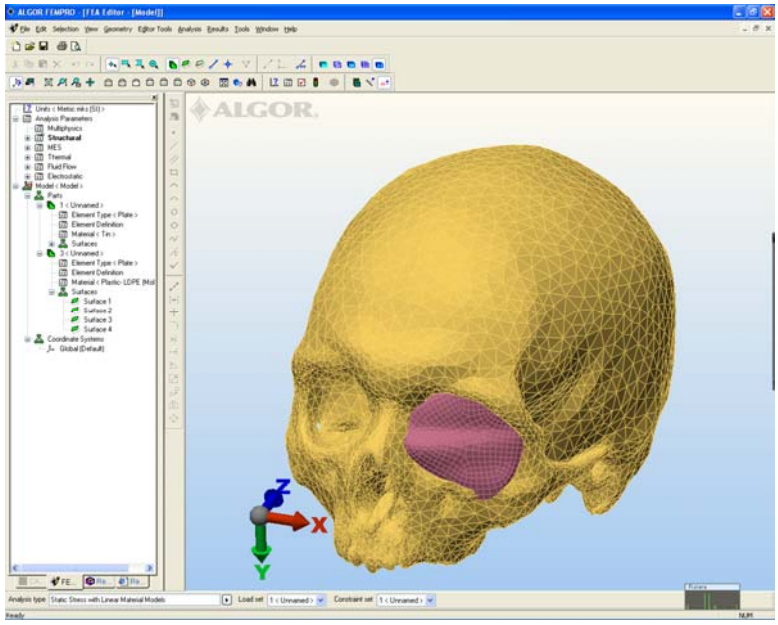

Fig. 2. Application of the maxillofacial prosthesis.

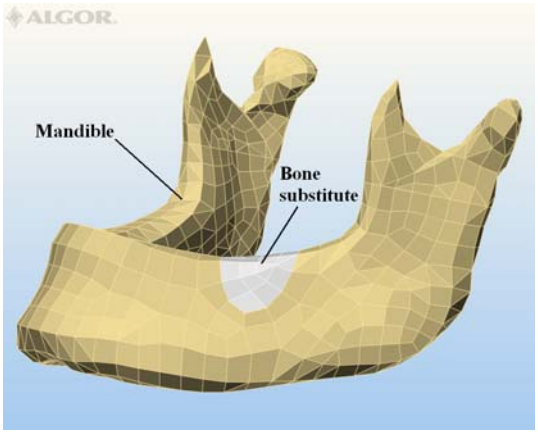

Fig. 3. Tension concentrators – finite element analysis.

Aspects of mathematical modeling for a substance loss at mandibular level highlighting the influence of action of the muscular factor over the future reconstruction (Fig. 4).

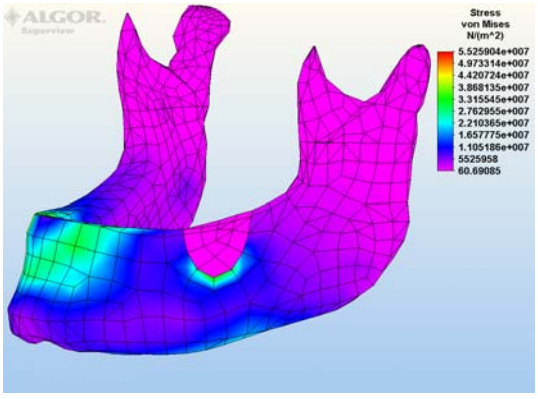

Fig. 4. Substance loss model at mandibular level.

Mathematical modeling and clinical applications for the extra-oral substance losses

The first case analyzed is that of simple sustaining of the maxillofacial prosthesis. We consider that pressure acts uniformly with a value of 20 Pa. We introduce the material conditions for the bone, soft tissue, silicon rubber and acrylate. We give the order Analyze, and the tension state resulted is illustrated in Figure 5.

In the previous figure we may notice that the maximal state of tensions, of about 2,5 Pa is encountered at the contact between implant and bone, the value being too low to irritate the skin with which it comes into contact (the irritability tension of skin is 2 MPa), but too little for the bone. Taking into account the fact that the muscular structures had not been excised, their action may sufficiently load the bone so that there is no bony resorbtion.

The second case is fixing the implant by four magnets that were attached to the bone beforehand. The simulation of such fixing is made by applying some punctual forces with the value of 10 N (Fig. 6). The attraction force among the magnets attached to the bone and the ones fixed on the implant must not be strong so as to allow the cleaning of the affected area.

In this case, the tension distribution is circular around the fixing points with a maximum value of 4.57 Pa. As it was mentioned above, this tension too is under the irritability degree of the dermal tissue and for the bone it is a tension allowing a load that might permit a correct generation of it.

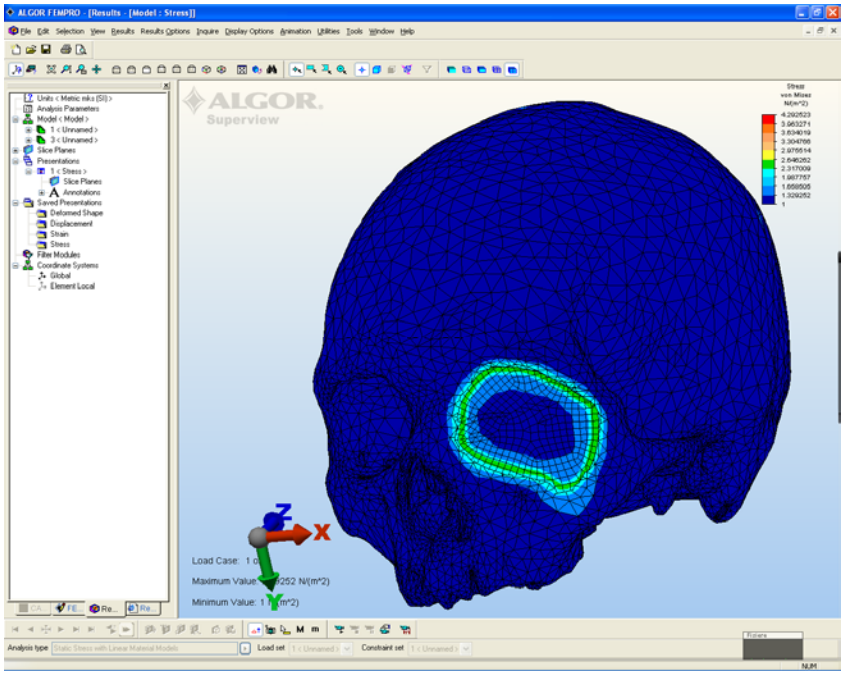

Fig. 5. Tension distribution in the case of simple sustaining of implant.

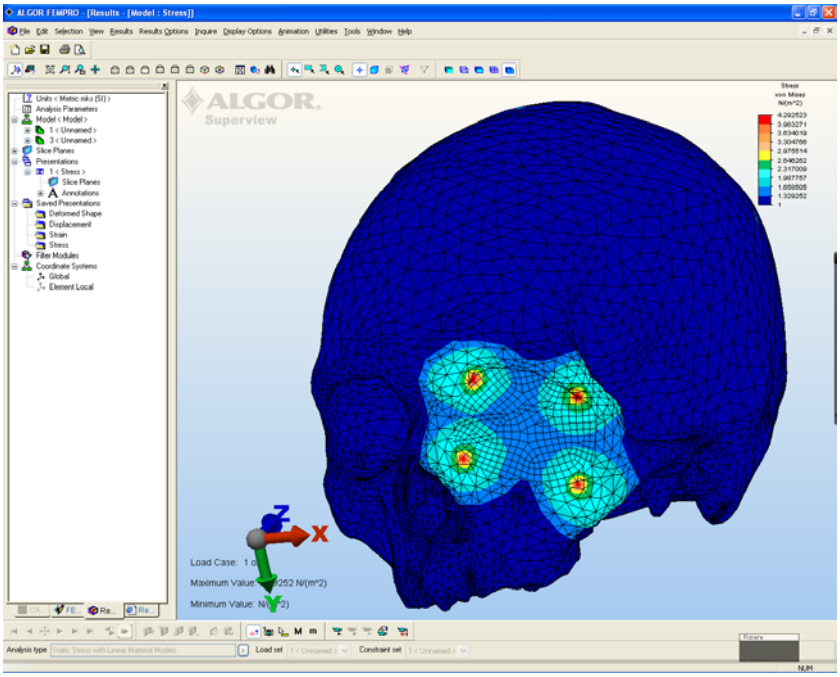

Fig. 6. Application of forces simulating the fixing of implant by magnets.

CONCLUSIONS

The oral rehabilitation of substance losses supposes a complex algorithm fully complying with the particularity of the clinical case.

The finality of the clinical case is in conformity with the biomaterials used, mainly silicon materials, without eluding the role of the filling biomaterials.

The stages of mathematical modeling personalized for each clinical case are very important in choosing the final therapeutic solution.

The simulation of the real clinical situations after the contribution of the computer tomography, whose images were processed by means of the universal program for 3D reconstruction Amira, associated to the discrete rendering of the mobile prostheses from flexible acrylate by means of the

Gambit 6.6.0 program, represents a highly important stage in evaluating the resorbtion and atrophy degree at the level of the toothless crests, a process whose parameters are influenced by a factorial cumulus with a deep impact on the clinical finality.

Lining the flexible prostheses with silicone of medium resilience leads to a diminution of the forces induced by the flexible prosthesis itself, as aspect reflected in the decrease up to the annulment of the masticatory pressures whose value is different depending on the patient's type of occlusion, the type of antagonistic arch, an important role being held by the type of restoration when this is chosen as a therapeutic solution.

The intra-oral substance losses associated to the resorbtion and atrophy processes have an optimal clinical solution by means of the flexible prostheses, where they interposed a silicon layer after having finished the adhesion process made for the first time on the territory of dental medicine at national level, what leads to the stopping of the existing phenomena.

The mathematical modeling of the real clinical situations offers optimal data to choose the treatment solution fully compliant with the parameters characterizing the substance loss, the type of biomaterial involved in the structure of the prosthetic substitute, and in the case of maxillofacial prostheses an important role is played by the fixing means.

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