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Definition Of The Intense And Deformable Jaw State Under The Masseters Hyper Tone

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Abstract- Current research considers the hypothesis of masseter muscle hyper tone as one of the factors for gingiva recession. By means of bio-mechanical modeling operation the three-dimensional solid-state model was constructed. Thus the assessment of movements and gingiva pressure intensity in areas of cutters and canines was made. The problem of intense strained state definition was solved using finite element method. The model allows to consider influences of chewing and temporal muscles. Problem definition is the linear isotropic, taking into account the following contact interactions: dentition – gum, gum — bone. In final element sampling the tetrahedral and hexsahedral finite elements from the linear approximation were used. Within calculation the masseter muscles hyper tone was modeled by applying pressure, force amounts thus used were equal to: 100 N, 300 N, 700 N, 1300 N in various combinations. The analysis of pressure intensity results for dentition showed that the maximal pressure arises in the cutters area. While applying different types of loading qualitative change does not take place, however, pressure intensity values change. The contact pressure assessment for areas of dentition contact among themselves and with jaw was made. The distribution picture is similar to a picture of pressure intensity distribution — larger contact stresses fall onto a place where cutters contact, at various schemes of loading the picture changes quantitatively. The detailed analysis of the results received is given in the article.

Keywords: bodily machinery (bio-mechanics), hyper tone, contact stresses, masseter muscles.

1. INTRODUCTION

Today the problem of gingiva recession development and treatment is an actual task that is bound to high abundance of pathology (45-99%). Despite the etiology and pathogenesis of gingiva recession being studied rather explicitly, there is no uniform hypothesis of the specified pathology nature formation. The open question is a role of masseter muscles hyper tone, being one of the factors for musculotonic syndrome manifestation in gingiva recession development. In available literature issues of gingiva recession development for patients with intact parodont and musculotonic syndrome are not fully covered. Within complex researches (clinical-and-radiological, clinical-and-laboratory and functional indexes for patients with musculotonic syndrome with and without manifestation of gingiva recession) the bio-mechanical model of jaw considering contact interaction of dentition among themselves and with gingiva under condition of masseter muscles hyper tone was constructed. The modern numerical methods enable us to build various models of dentoalveolar joint, to set geometrical as well as mechanical system parameters. Definition of rheological model of tooth structure, gingiva, as well as definition of their mechanical characteristics are relative objectives. The modern methods allow to estimate efforts of masseter muscles within 100-600 N in norm, thus m. masseter physiologically was implied [1-5]. In pathological states muscular pressure may rise up to 2-3 times [6-8].

2. RESEARCH METHODOLOGY

Within bio-mechanical research of tooth and maxillary system intense and deformable condition top (Fig. 1a) and under jaw (Fig. 1b) were considered. Thus the movement assessment and gingiva pressure intensity in the $A\text{-}A_1$, $B\text{-}B_1$, $C\text{-}C_1$, $D\text{-}D_1$, $E\text{-}E_1$, $F\text{-}F_1$ areas (Fig. 1) was made, influence of temporal muscles were simulated by forces applied in areas 1, 2 (Fig. 1), influence of masseter muscles were simulated by forces applied in areas 3, 4 (Fig. 1).

a b

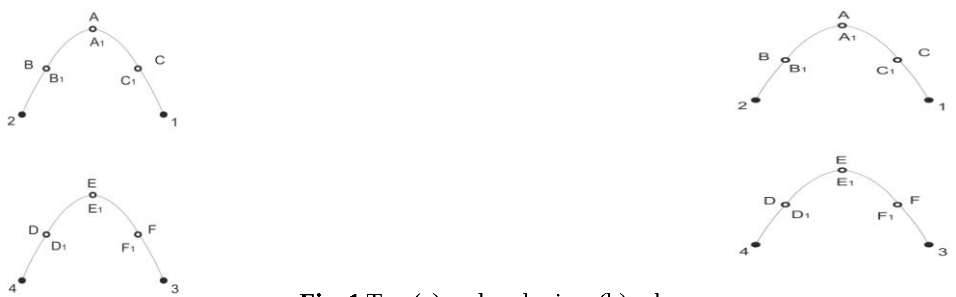
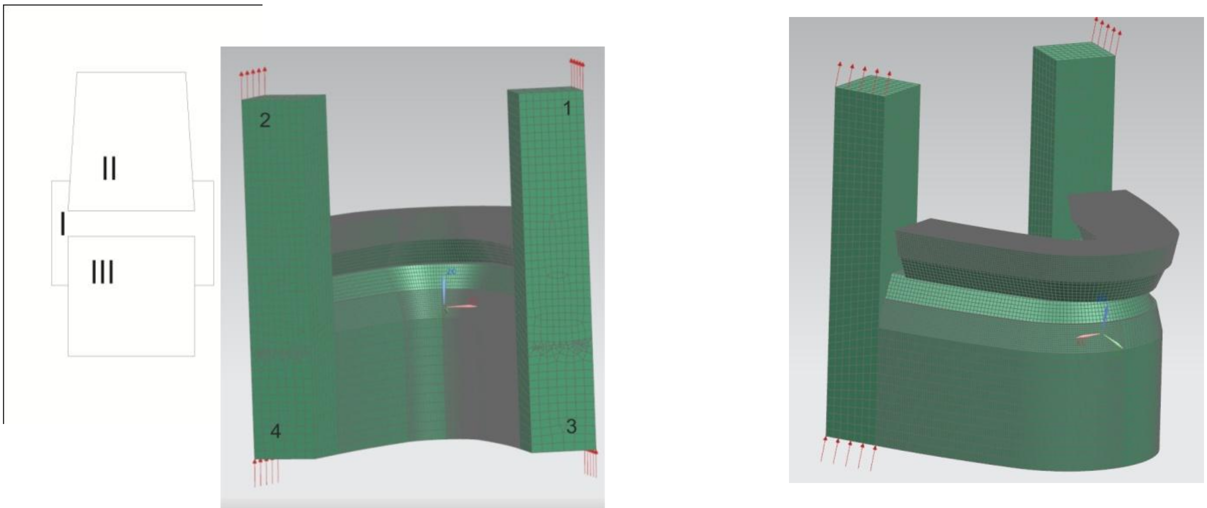


Fig. 1. Top (a) and under jaw (b) scheme

In operation modeling the three-dimensional solid-state model of jaw, dentition top and under jaws simulated by the homogeneous body was constructed. The problem of intense and deformable state was solved by a finite element method. Problem definition was linear isotropic, taking into account contact interactions of teeth, gingiva and jaw bone. Mechanical characteristics used in the task were: teeth - 2·106 MPa, bone - 1·106 MPa, gingiva - 1·105 MPa. Contact interaction was realized according to technique [9, 10], thus two areas of contact interaction were allocated: teeth-gums (areas I and II in fig. 2a), gum-jaw (areas I and III in fig. 2a).



a b c

Fig. 2 Contact model (a), final element model (b, c)

In final element sampling tetrahedral and hexahedral finite elements from the linear approximation were used (Fig. 2b, c), in model there were about $22 \cdot 10^4$ finite elements present. Within calculation the masseter muscles hyper tone was modeled (loading in areas 3 and 4), force values thus used were equal to: 100 N, 300 N, 700 N, 1300 N, - in different combinations [11, 12].

3. RESEARCH RESULTS AND DISCUSSION

The analysis of pressure intensity results for dentition showed that the maximal pressure arises in the cutters area. There are sharp jumps of pressure in the area of concentrators - dentition sides connected to dentition as well as numerical model tolerances. The assessment of pressure intensity in the A-A_1, B-B_1, C-C_1, D-D_1, E-E_1, F-F_1 areas was made. At different types of loading qualitative change does not take place, yet pressure intensity values change. It should be noted that the received pressure is top value as the model does not consider mobility of teeth to jaw and to each other.

The contact pressure assessment for areas of dentition contact among themselves and with jaw was made. the distribution picture is similar to a picture of pressure intensity distribution - larger contact stresses fall onto a place where cutters contact, at various schemes of loading the picture changes quantitatively. Let us give more detailed analysis to the received results. For descriptive reasons a half of dentition is given on images.

Pressure 100H. From external part of a mandible the maximal pressure in the cutters area reaches 45 MPa, on the top jaw at the basis of cutters the pressure is much lower (18 MPa). In the dentition interior at the basis of cutters maximal pressure on mandible is about 70 MPa, in the same area on top jaw it is about 40 MPa.

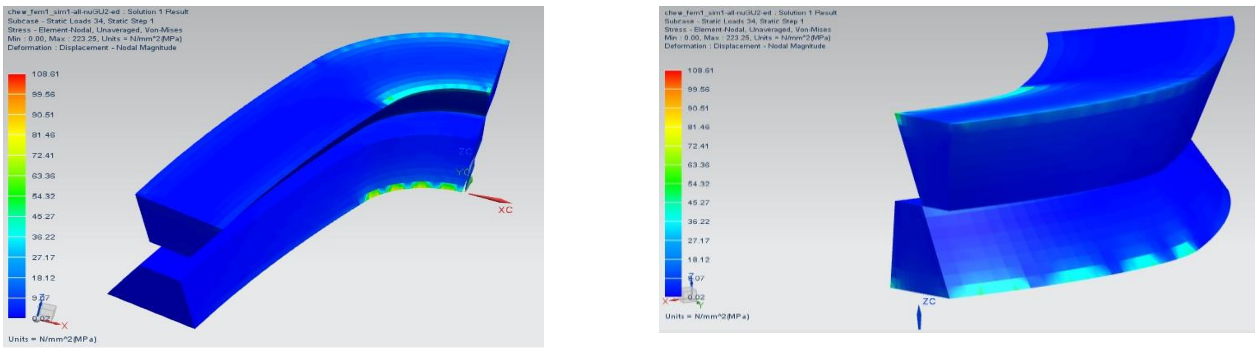


Fig. 3 Pressure intensity at 100 N loading

Pressure 300H. From external part of a mandible the maximal pressure in the cutters area barely changes and reaches 45 MPa, on the top jaw at the basis of cutters the pressure barely changes as well (18 MPa). In

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the dentition interior at the basis of cutters maximal pressure on mandible rises to 75 MPa, in the same area on top jaw it is about 40 MPa.

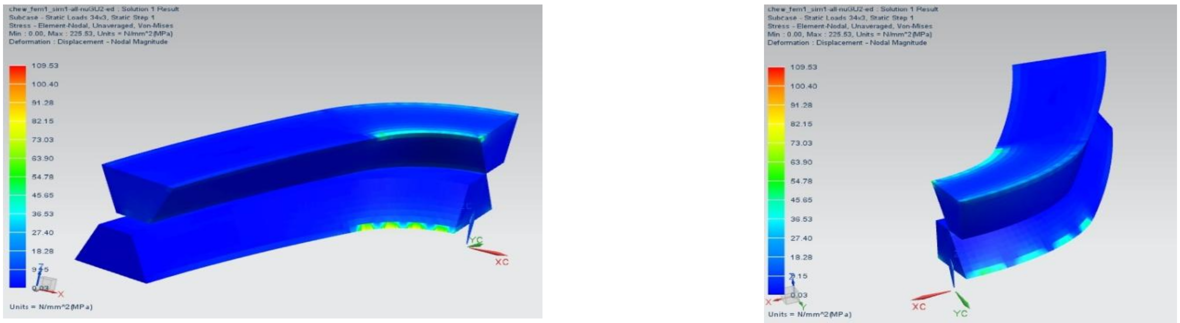

Fig. 4 Pressure intensity at 300 N loading

Pressure 700H. From external part of a mandible the maximal pressure in the cutters area reaches 55 MPa, on the top jaw at the basis of cutters the pressure stays in limits of 18 MPa. In the dentition interior at the basis of cutters maximal pressure on mandible rises to 80 MPa, in the same area on top jaw it is about 45 MPa.

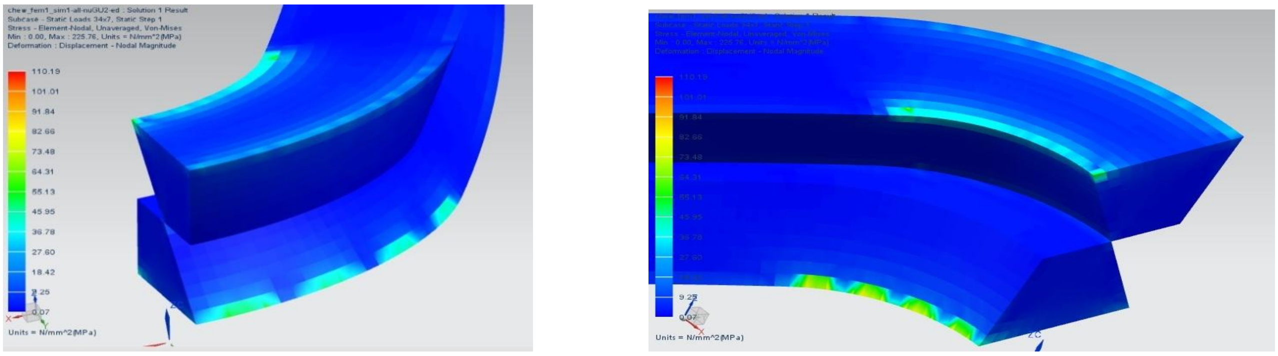

Fig. 5 Pressure intensity at 700 N loading

Pressure 1300H. From external part of a mandible the maximal pressure in the cutters area reaches 60 MPa, on the top jaw at the basis of cutters the pressure stays in limits of 18 MPa. In the dentition interior at the basis of cutters maximal pressure on mandible rises to 85 MPa, in the same area on top jaw it is about 55 MPa.

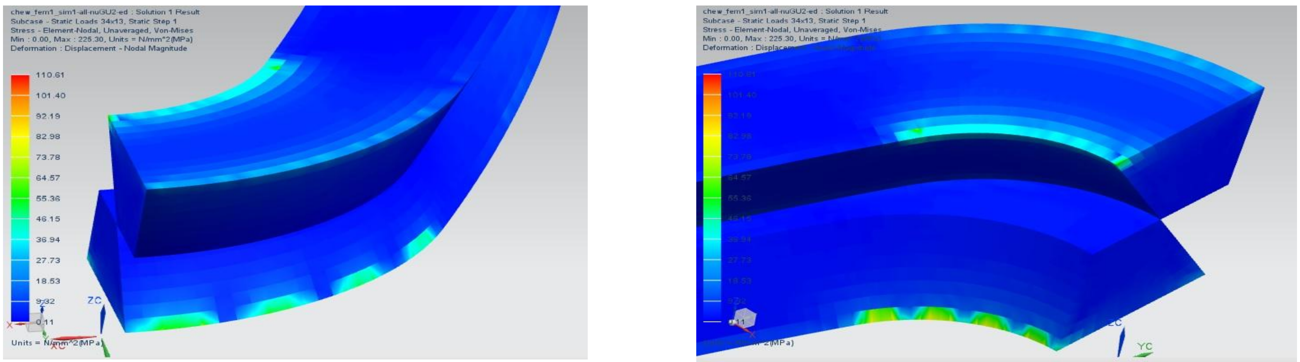

Fig. 6 Pressure intensity at 1300 N loading

The result analysis in gingiva movement showed that there is a vertical shift of gingiva to dentition, definitive feature of these movements in areas of top and under jaw cutters and canines is that they bare the dentition (the gingiva of the top jaw rises - possesses positive movements, the gingiva of the under jaw - falls, the negative movements).

4. SUMMARY

During assessment of one force influence on jaw distortion of movements is observed, thus movements on a counter site of force application are positive for mandible. The top jaw is less subjected to this effect as it is fixed more rigidly. At collateral influence of forces, the gingiva deviation from teeth surface is observed and in canines area. For the analysis of pressure factor influence on vertical movements in areas of interest, schedules and charts for more detailed analysis were made.

5. CONCLUSION

Thus, the stress distribution assessment in jaws at hyper tone of masseter muscles was carried out. On the basis of calculation results it is possible to claim the existence of the increased pressure areas in cutters and canines area that corresponds to the data obtained by results of clinical observation.

CONFLICT OF INTEREST

The author confirms that the presented data do not contain the conflict of interests.

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