International Academy of Science and Higher Education

# LIFE AND HEALTH OF THE PERSON THROUGH THE PRISM OF THE DEVELOPMENT OF MEDICINE, FOOD SAFETY POLICY AND PRESERVATION OF THE BIODIVERSITY

Peer-reviewed materials digest (collective monograph) published following the results
of the CVI International Research and Practice Conference
and II stage of the Championship in Medicine and Pharmaceutics, Biology, Veterinary Medicine and Agriculture
(London, August 26 - August 31, 2015)

**The event was carried out in the framework of a preliminary program of the project
"World Championship, continental, national and regional championships on scientific analytics"
by International Academy of Science and Higher Education (London, UK)**

Published by IASHE
London
2015

UDC 616.314.11:539.4

**MODELING OF A STRESS CONDITION OF HARD TISSUES OF A TOOTH IN THE PROCESS OF THE RESTORATION OF CARIOUS CAVITIES OF CLASS I**

**Yu.V. Lakhtin, Dr. of Medicine, Associate Prof.**
**Yu.V. Smeyanov, Assistant, Applicant**
**Sumy State University, Ukraine**

**Conference participants,**
**National championship in scientific analytics,**
**Open European and Asian research analytics championship**

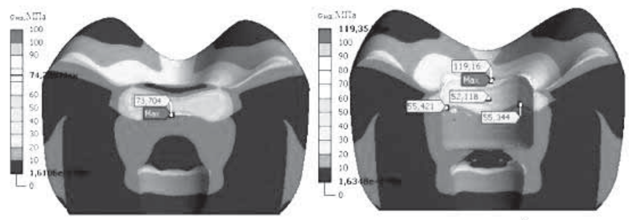
*To study the stress state of geometrically complex multilayer bio-mechanical system consisting of enamel, dentin and filling, the three-dimensional solid modeling on software package SolidWorks and mathematical analysis with finite element methods on program ANSYS Workbench were used in the research. In the mimicking, the tooth is seen as an elastically deformable body under static loading evenly distributed force. It is found that the inner stress in the hard tissue of intact tooth is maximum (74.2 MPa) in the area of application of the load. The maximum stress (119 MPa) in a restored over carious cavity of the I class tooth occurs in the area of enamel contact with the restoration.*
***Keywords*****:** *stress state, tooth, carious cavity, tooth restoration, dentine, enamel, finite elements method.*

**Foreword.** Longevity of teeth restorations has important clinical and social importance. The development of secondary caries, restorations losses lead to repeated visits of the patient to the dentist, and new preparation of hard tooth tissues. This can be a starting point for a number of morphological and functional changes not only in the teeth, but in teeth-jaw system as a whole. This repeated machine treatment leads to thinning of hard tooth tissues, development of cracks, fracture. In the process of preparing and dental restoration, a number of problems, that impair the conditions of restorative material holding in the carious cavity, can arise and that leads to a reduction in the useful life of restorations [1]. One of these problems is secondary caries. Its appearance possible in damage of marginal adaptation of filings due to the properties of restorative material, polymerization stress, its contraction and elastic modulus [8, 13], the carious cavity configuration factor [11].

Recently, experts are increasingly focused on the role of mechanical properties of dental tissues in high quality marginal adaptation of the material. Tooth tissues have a wide range of mechanical properties [10]. Even with high-quality preparation and restoration of cavities during functional load in the tissues of the tooth own stress takes place leading to cracking of dentin and enamel, damage of marginal seal, resorption and loss of material [5]. Stress state of hard tooth tissues was studied during endodontic treatment [3], restoring of V class cavities [7], recovery with artificial crowns [6], occlusal loads in detail [9]. We did not encounter in accessible publications any information on the stress state in the tissues of the tooth, restored over the I class carious lesions.

**The objective** of our research is the study of the stress in tooth hard tissues at computer modeling of restored carious cavities of Class I that are prepared in a classical way.

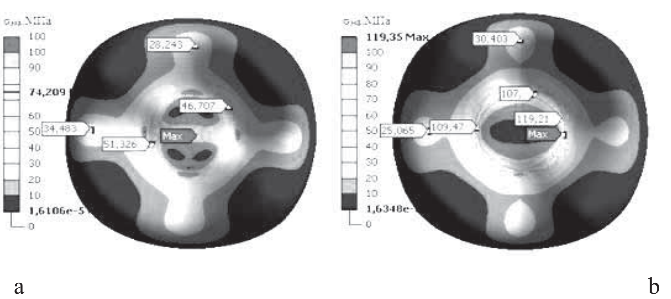
**Methods**. A three dimensional model "Enamel – dentine – restoration" has been created on the basis of x-ray image of the lower molar by means of the program SolidWorks, then it has been exported to the program complex ANSYS Workbench, and a final element model has been formed (**Fig. 1**). The equivalent stress has been calculated by von-Mises on condition that the root part of a tooth is accurately fixed, all components of the model are isotropic, a vertical uniaxial charge according to the tooth center 500 H.



a b

**Fig. 1. The finite element model of the intact tooth and restored**

**Results**. Under the influence of the vertical charge on the model in the intact tooth on the bite surface, the tensions in the enamel correspond topographically to the projection of fissures of molars (**Fig. 2a**). Several stress fields are identified there, they are spread concentrically from maximum values in the place of the action of the charge to minimum values to the perimeter of fissures. The first field is formed in the place of the action of the vertical charge, the maximum stress is 74.2 MPa. The second field is localized around the first one, it has lower values of the stress up to 50 MPa. The values of the third one decrease up to 25-30 MPa. Isolated stress areas up to 35 MPa are determined in the zone of medial and distal edge. The fourth stress field possesses the lowest values – 10-20 MPa.

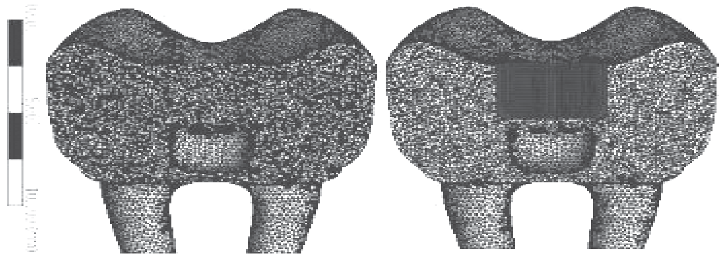


a b

**Fig. 2. Areas of stress in the enamel on the occlusal surface: intact tooth (a), restored (b).**

The character of the stress in the enamel in a restored tooth is the same as in the intact tooth (**Fig. 2b**). But the first field starts around the filling, the maximum stress value in the enamel is 119 MPa that is 60 % higher than in the intact tooth. The second stress field is about 100 MPa (100% higher than the intact one).

In the sagittal section of the intact tooth in the place of the charge the stress of the whole thickness of the enamel is 52-55 MPa, it reaches its maximum (74 MPa) in the area of enamel and dentine border. The values in the dentine decrease to 10 MPa. The same stress force is also determined in the neck area of the enamel and dentine (**Fig. 3a**).



**a** **b**

**Fig. 3. Zones of stress of tooth tissues in the sagital area: intact tooth (a), restored (b).**

In the restored tooth in the upper layers of the filling the same stress is created like in the enamel of the intact one (52-55 MPa). Moreover, in the area of the direct contact of the filling with the enamel, it increases almost up to 120 MPa. The stress force of hard tissues decreases to 10-15 MPa in the thickness of the cover dentine as well as in the neck area (**Fig. 3b**).

**Discussion.** Thus, the stress in the solid tissues of intact and restored teeth has different meanings. In the study we examined the components of the model «enamel-dentine-filling» as isotropic materials, but the physical properties of the tooth are uniform. Anisotropy of dentin ensures the availability in its structure a tubular unit, and in enamel - prismatic structure [6]. Renewing material also has anisotropy due inorganic filler. That is, each component of the model «enamel-dentine-seal» has its own physical characteristics, especially elastic modulus. If this module in each component is different, the stress in them distributes unevenly both upward and downward. Much tension arises in the element of the model, whose elastic modulus is higher [2]. In our study it is shown that stress is much higher in the enamel, which is directly in contact with the filling material. It may be a risk factor for deformation in enamel with the gradual weakening of its structure and development of micro-cracks, defects that lead to damage of marginal adaptation of restoration. Given this fact, it is necessary to use a recovery material which has a similar or close elastic modulus of the tooth, to strengthen their structure [12] and also to carry out further research on optimization methods of forming of carious cavities, especially treatment of enamel margin.

Stress increasing in the enamel of intact tooth on enamel-dentine limit can be explained by the peculiarities of the role of hard tissue with functional load and also higher elastic modulus in enamel. Mechanical role of the enamel is to protect dentine because of its high wear, and mechanical role of dentine is to absorb the power load because of its high strength resistance [4].

Stress state of a cervical part of intact and restored tooth resulting from the transfer of reactive power from the surface of load through the enamel-cementum junction to root, and then in the alveolar bone. These forces can cause stress in remote areas from the point of force application [7].

**Conclusions.** The stress in hard tissues of the intact and restored tooth has different values. Under the vertical uniaxial charge on the restored tooth with decay of Class I of the molar of the lower jaw, the maximum stress appears on the border of the direct contact with the restoration.

**References**

1. Боровский Е.В. Качество препарирования полостей класса I и II., Е.В. Боровский, С.Н. Носикова., Сборник научных трудов SWorld : Материалы международной научно-практической конференции «Современные направления теоретических и прикладных исследований '2012». – Вып. 1, Т. 30. – Одесса., КУПРИЕНКО, 2012., С. 27-29.
2. Трехмерное математическое моделирование напряженно-деформированного состояния зуба и пломбы., Е.Ю. Шелковников, А.И. Кириллов, С.М. Ефремов, Т.Л. Рединова, А.А. Тимофеев, Т.Ю. Метелева., Ползуновский альманах. - 2014., No. 2., С. 54-58.
3. Ausiello P. Mechanical behavior of post-restored upper canine teeth: A 3D FE analysis., P. Ausiello, P. Franciosa, M Martorelli., Dental Materials. – 2011.,Vol. 27, No. 12., pp. 1285–1294.
4. Chun K.J. Comparison of mechanical property and role between enamel and dentin in the human teeth., K.J. Chun, H.H. Choi, J.Y. Lee., J Dent Biomech. - 2014. - Vol. 5., doi: 1758736014520809.
5. Class I and Class II restorations of resin composite: An FE analysis of the influence of modulus of elasticity on stresses generated by occlusal loading., E. Asmussen, A. Peutzfeldt., Dental Materials. - 2008. - Vol. 24, No. 5., pp. 600–605.
6. Dejak B. Three-dimensional finite element analysis of molars with thin-walled prosthetic crowns made of various materials., B. Dejak, A. Mlotkowski, C. Langot., Dental Materials. - 2012., Vol. 28., pp. 433-441.
7. Effect of occlusal restoration on stresses around class V restoration interface: A finite-element study., G. Vasudeva, P. Bogra, V. Nikhil, V. Singh., Indian J Dent Res. - 2011., Vol. 22., pp. 295-302.
8. Factors influencing marginal cavity adaptation of nanofiller containing resin composite restorations., H. Takahashi, W. J. Finger, K. Wegner [et al.]., Dental Materials. – 2010., Vol. 26, No. 12., pp. 1166–1175.
9. Fracture simulation of restored teeth using a continuum damage mechanics failure model., L. Haiyan, L. Jianying, Z. Zhenmin, A.S.L. Fok., Dental Materials. – 2011., Vol. 27., pp. 125-133.
10. Fusayama T. Total etch technique and cavity isolation., T. Fusayama., J Esthet Dent. – 1992 (4)., pp. 105-109.
11. Influence of C-factor and light-curing mode on gap formation in resin composite restorations., G.O. Santos, M.E. Santos, E.M. Sampaio [et al.]., Oper Dent. – 2009., Vol. 34., pp. 544-550.
12. Monoblocks in root canals: a finite elemental stress analysis study., S. Belli, O. Eraslan, G. Eskitascioglu, V. Karbhari., International Endodontic Journal. - 2011., Vol. 44., pp. 817-826.
13. The influence of different restorative materials on secondary caries development in situ., F.H. Sande, Niek N.J.M. Opdam, G.J. Truin [et al.]., Journal of Dentistry. - 2014., Vol. 42, No. 9., pp. 1171–1177.