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PROSPECTS FOR THE USE OF A PRECISION METHOD FOR MANUFACTURING INDIVIDUAL MOUTHGUARDS FOR THE INTRODUCTION OF DOSAGE FORMS INTO THE FOCUS OF ENAMEL DAMAGE IN WEDGE-SHAPED DEFECTS

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Abstract:

In this article, the search for new minimally invasive organ-preserving techniques and methods of their implementation in the treatment of wedge-shaped defects within the enamel is updated. A personalized approach to decision-making related to the treatment of this type of pathology is objectified. Emphasis is placed on the pathogenetic mechanism of this process, taking into account morphofunctional changes in enamel. Changes in the architectonics of the enamel layer of the tooth and its elemental composition were studied and discussed. A hypothesis is made and an option is proposed for creating a drug depot, which is a method of delivering dosage forms to the affected area to create an isolated contact with the hard tissues of the tooth. The purpose of this study was to develop an algorithm for creating precision manufacturing of individual mouthguards for targeted delivery and creation of an isolated depot of dosage forms in the area of enamel damage in a wedge-shaped defect. The scientific basis and principles of the research concept consisted of data obtained on microstructural transformations, changes in the elemental composition of the tooth with a wedge-shaped defect. It is proved that oxygenation increases against the background of a decrease in carbohydrate compounds, there is a decrease in the content of fluorine and sulfur is present in the lesion. The results obtained were the basis for the application of a targeted and personalized algorithm for treating this pathology, using 3D technologies. The results of which can be integrated into the concept of minimally invasive, organ-preserving methods of providing dental care to patients with initial forms of wedge-shaped defects. The study was conducted with the involvement of 38 patients, age and pathology describe, creating a Mat model of the Capa taking into account the volume of the tooth itself and Pro to create a model of the defect within the anatomical shape of the tooth and its location in the dentition mathematical modeling.

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INTRODUCTION:

The prevalence of non-carious diseases has increased significantly in recent years [1]. In Russia, the frequency of occurrence has reached 70%[2]. And with such a high prevalence, the trend of increasing morbidity remains unchanged [3].

Among the damage to the enamel non-carious nature of wedge-shaped defects of hard dental tissues, formed after the eruption are of particular relevance and importance [10]. In the structure of dental pathology associated with non-carious manifestations, they take the lead place, due to their high prevalence (22% -82%) in different regions of the country [1,5]. In addition, in the last twenty years, the progression vector of this pathology has shifted towards rejuvenation [2,5]. Having a tendency for dynamic development and frequent relapses.

According to Russian and foreign literature, the wedge-shaped defect as a pathology has been known for a long time, while there is still no unified point of view on the main links of pathogenesis [7-9] and the problem requires further study.

One of the modern trends in the field of world dentistry is the use of minimally invasive, organ-preserving and personalized techniques in solving dental problems in each specific clinical case [2]. From the position of this paradigm, we would like to look at the issues related to the opportunity of using these techniques in the treatment of non-carious lesions, in particular, a wedge-shaped defect [7].

Existing methods of treating a wedge-shaped defect are either aggressive or short-term in nature and the stabilization of the process often does not occur. Special interest is directed to the study of non-invasive methods of treatment, which is undoubtedly based on accurate knowledge of the enamel microstructure in normal and normal pathology [11].

Modern dentistry increasingly offers a personalized approach to the treatment of various types of pathology of the dental system [8,10]. Active implementation of additive technologies in the usual work makes it possible to plan treatment individually, presenting the doctor with the opportunity of local integration of the active substance into the lesion, making long-term results more predictable [1,5].

The emerging science of nanotechnology, especially in medicine and dentistry in particular, is generating research interest in potential applications and its advantages over the use of traditional materials. To understand how nanomaterials can be used in everyday practice, it is necessary to better understand the structure of enamel damage and the mechanism of the substance [4].

This paper presents the results of the development of a modern concept for the treatment of wedge-shaped non-carious defects of the enamel layer of teeth, based on the personification of non-invasive methods of therapy, the use of additive 3D printing technologies [4]. Application of the developed concept of in vitro therapy will allow to achieve remineralization of the enamel layer of teeth damaged by a wedge-shaped defect, improve their architectonics and its elemental composition [6].

PURPOSE

To develop an algorithm for creating precision manufacturing of individual kapp dosage forms for targeted delivery to the zone of enamel damage with a wedge-shaped defect.
Materials and methods

Previously, we conducted a clinical-experimental, prospective, controlled study, where our area of interest was focused on the initial manifestations of the wedge-shaped defect, since this determines the choice of non-invasive techniques.

The disease was classified as localized on the enamel layer of the tooth, slit-shaped with a loss of hard tissue no more than 0.2 mm deep,3-3. 5 mm long, which did not contradict both basic and modern classifications.

The work was performed in the laboratory of electron microscopy and small-angle x-ray diffractometry using a raster electron microscope Quanta 200 i 3D FEI (USA) with a system of energy-dispersive microanalysis. The material of the study was dental plumes obtained using the Hm 450 microtome in vitro from teeth removed according to orthodontic indications that have a wedge-shaped defect on their surface. According to the analysis of the results of electronic copies of tooth grinding, changes in the enamel architectonics, the presence of cracks along the course of enamel prisms, the randomness of their distribution, the presence of pores in the lesion (Fig. 1). In the area of the wedge-shaped defect, there is a zone with focal demineralization of the enamel.

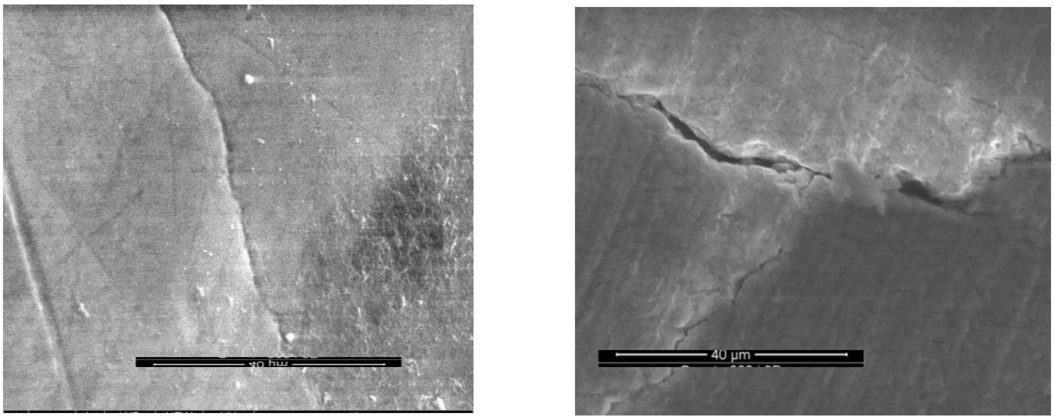


Figure 1. The surface of the enamel in the lesion of the sphenoid defect, the SEM was taken. 3000

The chemical composition of enamel in the affected area of the defect (Fig.2) showed an increase in oxygenation, while reducing the number of carbon compounds, reducing the content of fluorine, sulfur appears in the composition, which most likely confirms the change in the crystal structure of hydroxyapatite. The ratio of the calcium-phosphorus ratio was 1:0.7, which indicates the processes of demineralization.

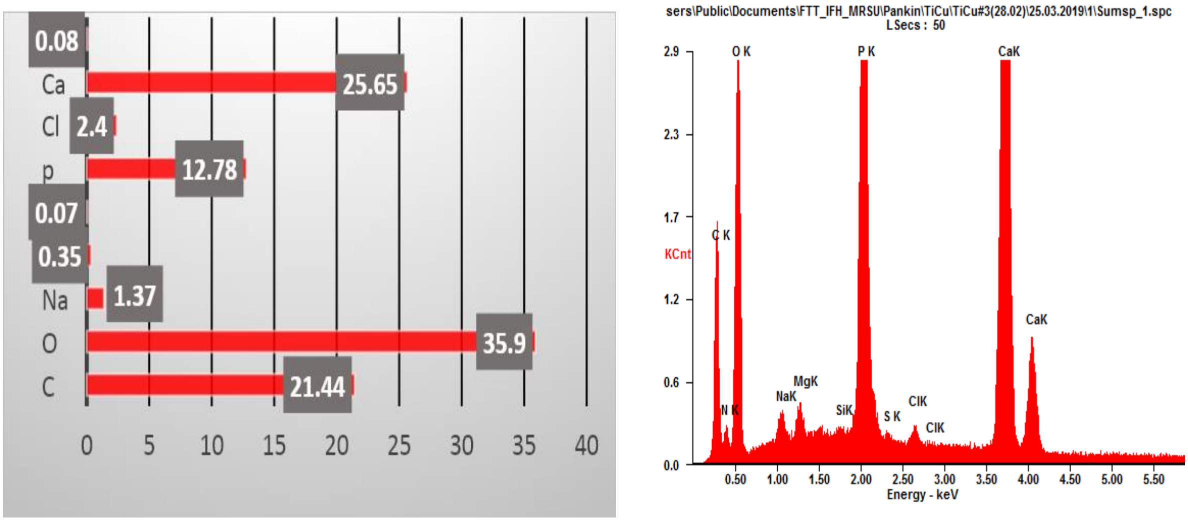


Figure. 2. Elemental composition of tooth enamel with a wedge-shaped defect

The results obtained made it possible to perform statistical data processing, indicating statistical reliability ($p < 0.05$, confidence probability of 95%).

As a result of research and previously obtained results, an algorithm was developed for creating precision models of jaws for the production of individual mouthguards, as a method for targeted delivery of dosage forms to the hard tissues of the tooth damaged by a wedge-shaped defect.

Methods: clinical, laboratory, analytical, optical, morphological, statistical.
The technology algorithm included a number of follow-up actions:

1. removing impressions of the upper and lower jaws using silicone on plastic spoons (Fig. 3)

figure 3

2. creating a plaster model of the jaws based on impressions (Fig. 4)

figure 4

3. 3D scanning of the plaster model of the jaw to obtain its virtual three-dimensional prototype (Fig. 5.)

figure 5

4. loading a virtual 3D prototype of the jaws into the software "Autodesk Meshmixer" (USA) using the "import 3D models" function (Fig. 6).

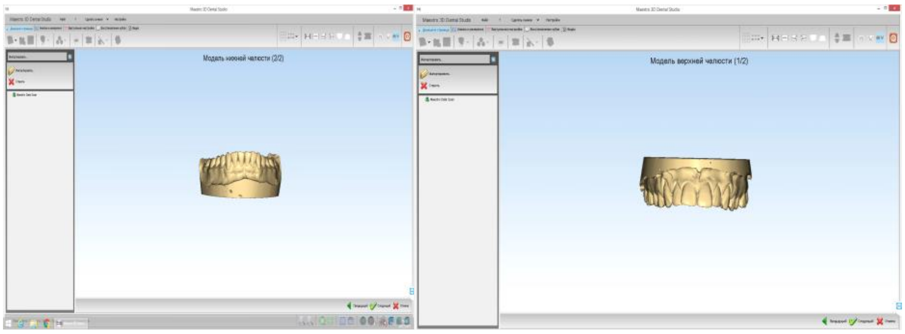


figure 6

5. determining the area of the tooth and the area of the defect on the resulting virtual 3 D layouts. Formula for calculating the area of the actual tooth surface:

$$S = c \cdot \left(h + \sqrt{(H-h)^2 + b^2}\right)$$, where c, H, h and b are individual parameters.

Formula for the surface area of a cavern with a minimum characteristic size r and a maximum-R:

$$S_c \cong 4\pi r R$$

.

6. Hybrid parametric modeling of the affected teeth. Figure 7

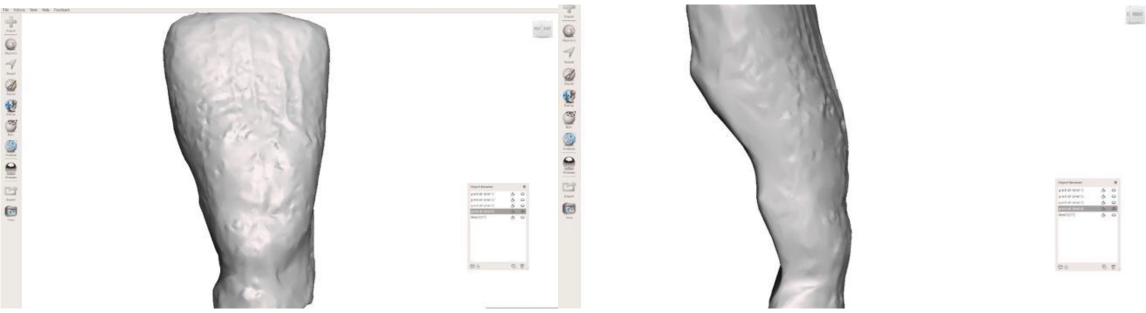
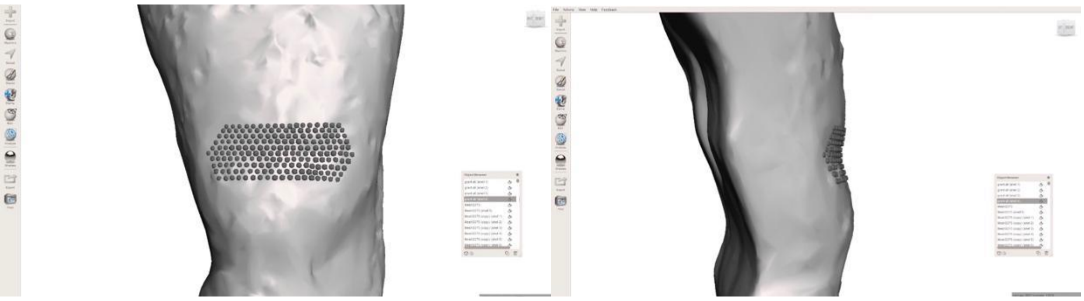


figure 7

7. taking into account the data obtained at stage 5, reference points are applied to the area of the tooth affected by a wedge - shaped defect, which will then be transferred to an individual mouthguard (Fig.8).



8. the jaw models Created in the SOFTWARE are exported in .stl format for subsequent 3D printing on a SLA 3D printer made of photopolymer material (Fig. 9)

Figure 9 Creating 3D models of jaws.

9. printing models of jaws on an SLA 3D printer made of photopolymer material. Figure 10

Figure 10 Printed layouts of the upper and lower jaw

10. the method of vacuum forming is used to produce an individual mouthguard (Fig. 11)

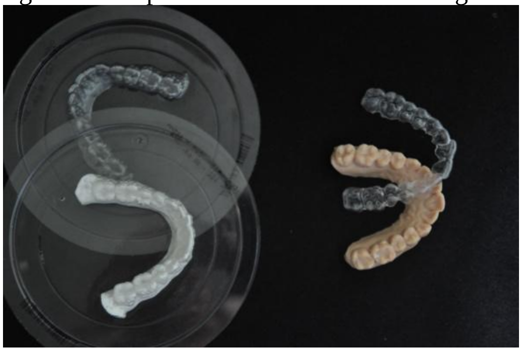


Figure 11 individual mouthguards made by vacuum forming

11. individual mouthguards are cut and sanded in a technical laboratory

Figure 12. Individual Kappa with reference points for targeted delivery of dosage forms to the hard tissues of the tooth damaged by a wedge-shaped defect.

In order to assess the precision of the jaw layouts created using the developed algorithm, a study was conducted in which 38 patients were included. Using the randomization method (random number generator) they were divided into 2 groups: 1 - the creation of layouts was made according to the developed algorithm (n=19), 2 - the creation of layouts was made according to the traditional method (n=19). According to the results of the study, it was proved statistically reliable ($p<0.05$) that the highest accuracy of matching the localization parameters of reference points for targeted delivery of dosage forms on the models of the jaws was obtained in group 1. Thus, the use of the developed algorithm allows us to accurately achieve the planned parameters of non-invasive treatment of teeth affected by a wedge-shaped defect in the enamel layer.

CONCLUSION:

So, a personalized, non-invasive, precision approach to the treatment of dental pathology in the form of a wedge-shaped defect of hard tissues of the teeth, located within the enamel, will allow: to purposefully deliver to the lesion medicinal forms whose size refers to the natural mineral phase of the tooth, which can easily penetrate the pores on the surface of the enamel, conduct local remineralizing therapy, reduce the risks of complications (focal demineralization of the enamel), achieve the desired aesthetic result, make the provision of dental care at a high-tech level.

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