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Rationale for the preservation of vital pulp in the use of fixed dentures in the experiment

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Abstract

The study aims to investigate rationale for the preservation of vital pulp in the use of fixed dentures in the experiment. In study, a comparison of traditional and air-abrasive methods of preparation was carried out in the laboratory. As a result, it was revealed that the air-abrasive method is more sparing to the tissues of the tooth, preserving the integrity of the dentin and enamel. In conclusion, the results of enamel X-ray microanalysis confirmed that content of the chemical elements F, P, Ca in healthy dental tissue is within the given ratio, but it significantly depends on the preparation technique.

Keywords: Electron microscopic study, Microanalysis, Tooth.

Justificación de la preservación de la pulpa vital en el uso de prótesis fijas en el experimento

Resumen

El estudio tiene como objetivo investigar las razones para la preservación de la pulpa vital en el uso de prótesis fijas en el experimento. En el estudio, se realizó una comparación de los métodos de preparación tradicionales y abrasivos con aire en el laboratorio. Como resultado, se reveló que el método abrasivo al aire es más conservador para los tejidos del diente, preservando la integridad de la

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dentina y el esmalte. En conclusión, los resultados del microanálisis de rayos X del esmalte confirmaron que el contenido de los elementos químicos F, P, Ca en el tejido dental sano está dentro de la proporción dada, pero depende significativamente de la técnica de preparación.

Palabras clave: Estudio microscópico electrónico, Microanálisis, Diente.

1. INTRODUCTION

The relevance of the study is associated with the high prevalence of dental diseases requiring orthopedic treatment. According to various data, the prevalence of these diseases, depending on the region, can approach 100% in older age. Researchers note a significant proportion of complications after orthopedic dental treatment, reaching 73% in the long term after prosthetics. Mistakes made at the stages of dental prosthetics, reduce its quality and form a negative attitude of patients to medical measures. As a consequence, it is possible to observe the dissatisfaction of the population with orthopedic care.

2. THEORETIC FOUNDATION

The provision of high-grade medical care is one of the modern problems of practical dentistry. The most common structures today are non-removable prostheses that meet modern aesthetic, hygienic, and technical requirements (ADDY & WEST, 2013).

Fixed structures have much greater aesthetics compared to direct restorations, due to the fact that they are created in the laboratory. They do not require finishing after fixing. In this regard, their surface is much smoother and it is less fixed dental deposits. Thus, indirect restorations help to improve the level of hygiene. Since indirect restoration is made in the laboratory, it is devoid of the lack of composite filling materials, which shrink during polymerization and experience polarization stress. Artificial crowns can withstand a lot of mechanical stress during mastication as compared to direct restorations. Due to the fact that the artificial crown covers the entire contour of the tooth, it carries out the prevention of chipping off the walls of the tooth (CHANG, HUNG, CHEN, TSENG, CHEN & WANG, 2019).

The use of metal-ceramic frameworks, as well as any other non-removable prostheses supported by the teeth with preserved pulp, has undeniable clinical and biological significance in the prediction of long-term results. The vital tooth does not change in color and as a consequence does not Shine through the edge of the artificial crown. Teeth with preserved pulp retain full strength, due to which the tooth retains its mechanical strength. Adhesion of cement for fixing fixed dentures is higher when working with vital teeth.

Odontopreparation in orthopedic dentistry is an important and integral stage of treatment and is a mechanical process of removing hard tissues of the teeth in order to create a prosthetic space. At this clinical-stage of treatment, a number of errors associated with incorrect selection of the instrument, non-compliance with the modes of preparation, deviation from the recommended algorithms of preparation, etc. are possible. Among the most significant consequences of such errors are noted: trauma of the marginal periodontium, insufficient quality of the formed stump, especially in the ledge area, the development of inflammatory changes in the tissues of the marginal periodontium and the deterioration of pink aesthetics in the ledge area, the development of secondary caries in the long term after treatment (AHMAD & AHMAD, 2018; AHMAD & SAHAR, 2019).

Despite the progress in dental materials science and the introduction of new medical and diagnostic technologies, clinical and technological Parallels between the type of applied dental burs and the algorithm of their application on the one hand and the outcome of orthopedic dental treatment with fixed prostheses on the other remain insufficiently studied.

However, the total preparation of the abutment teeth causes a number of complications at the stage of prosthetics and after its completion (AKHLAGHI & KHADEMI, 2015). There is overheating of the tooth tissues, which can lead to pulpitis. At the same time, low-frequency vibration has a negative effect on enamel microstructure. Tooth preparation causes morphological and functional changes in dental tissues potentially leading to pre- and postoperative complications, pathological processes in the pulp and periodontium and dental hypersensitivity (CHANG, HUNG, CHEN, TSENG, CHEN & WANG, 2007, AHMAD &AHMAD; 2018).

According to modern theories, the leading damaging factors are thermomechanical trauma, arising changes in organic and mineral components, contributing to the violation of their biological relationship and the integrity of the system. The disintegration of hard tissues leads to the launch of mechanisms of auto process and reactive inflammation of the pulp of the supporting teeth, developing with different intensity. In clinical conditions, it is often not possible to reliably determine the degree of inflammatory reaction and the prospect of its resolution (EVSTRATENKO, SEVBITOV, PLATONOVA, SELIFANOVA, DOROFEEV, 2018).

Statistical data on the frequency and nature of complications in hard tissues, pulp, and periodontium, some subtle mechanisms of pathology development after orthopedic treatment, the results of long-term observations of the state of the supporting teeth identified the main ways of influencing pathogenic factors in order to prevent complications. The search for the most advanced methods of odontopreparation, improving the structural characteristics of hard tissues, the use of new classes of synthetic materials of pathogenetic impact, the use of achievements of adhesive technology is conducted in different directions.

This problem may be solved by using air abrasion systems on the prepared tooth surfaces. Air abrasion devices create a micro rough adhesive surface free from mechanical contaminants (HAGIWARA, 2019). This technique minimizes the risk of micro-traumas, chips, thermal stresses, enamel, and dentin cracking. The above method allows opening the dentinal tubules for the use of modern adhesive systems without irritating the pulp or causing pain. The aim of the work was to study microscopic changes with a quantitative determination of trace elements (Ca and P) at the preparation boundary in the hard tissues of the tooth, after traditional preparation and with subsequent treatment with an air-abrasive device when preparing vital teeth for fixed prosthetics (ENINA, SEVBITOV, DOROFEEV & PUSTOKHINA, 2019).

3. METHODOLOGY

For this purpose, we examined 22 samples of human teeth extracted according to clinical indications. To establish the nature of the surface, the teeth were divided into two study groups, 11 samples in each group. The first study group included samples of traditionally prepared teeth. The second study group included samples of teeth treated with the Sandman Futura air abrasion device after traditional preparation.

Samples preparation for electron microscopy included passing dental material through a series of alcohols in increasing concentration and full dehydration in 100% acetone for 1-1.5 hours. To remove the charge-up conductive layer of high purity silver (99.98%) was deposited on the specimen in the working chamber of the VUP-5 universal vacuum station. Residual pressure was 2 10-3 mmHg or less. The thickness of the applied silver coating was regulated by the intensity/evaporation time ratio at 1–1.5 min intervals. Visual inspection was performed through the windows of the vacuum chamber.

The surface was studied on SELMI REM - 106 and JEOL JSM 6390 scanning electron microscopes at magnifications x12-5000 times, working distance WD 7.5-36.5 mm, accelerating voltage 15-22 kV, electron probe current - 65-95 μA. The image was formed in secondary electrons (SE) and in backscattered electrons (BSE-Compo), depending on the type of surface (LIATI, 2014).

X-ray microanalysis of the prepared surface was carried out using the RMA system (energy-dispersive X-ray microanalyzer) of a JEOL JSM 6390 electron microscope. The range of elements for microanalysis is from 5B to 92U. The energy dispersion resolution of the X-ray spectrometer on the Mn Ka line is not more than 143 eV. For the study, arbitrary sectors of the tooth tissue surface were selected that corresponded to the tasks to determine the chemical composition of dentin and enamel with a qualitative and quantitative analysis of the elements F, P, Ca. Before starting work, permission was obtained to conduct research In the local ethics Committee of Sechenov University (LIATI, 2019).

4. RESULTS AND DISCUSSION

Microfractograms show the traces of dentin fiber components presented by collagen fibers. The most common structures of crown dentine are S-shaped tubules, presenting an ordered system on microfractograms (Fig. 1). The number of dentinal tubule orifices in different samples is varied depending on patient age and level of mineralization. The assessment showed that in the 1st study group content of calcium and phosphorus in enamel was 43.29% and 17.09%, respectively, in the dentin - 39.73% and 14.66% (the spectrum of dentin minerals is presented in Fig. 1b, Table. 1). Obtained data generally characterized the total level of the studied elements that make up both organic and inorganic compounds.

The use of traditional preparation techniques for the samples of the 1st group led to a significant destruction of enamel prisms for a considerable distance from the wound edge (LIATI, SCHREIBER, ARROYO, DIMOPOULOS, 2018: SAZESH & SIADAT, 2018).

A large number of microcracks and chipped dental tissue were observed, the average size of defects was about 2-5 μm (Fig 1b). Violation of the integrity of enamel prisms led to their non-viability, demineralization and, as a result, to hard tissue hyperesthesia. Smallest dust fragments of dental enamel-covered a significant area of the tooth surface. Considering that the diameter of dentinal tubules is 2-5 μm, in such conditions microparticles of dental hard tissue significantly obstruct dentinal tubules and form the so-called smear layer, creating micro gaps between the surface of dentin and adhesive material. Also, a large number of damaged dentinal tubules create favorable conditions for penetrating bacteria into the pulp with the subsequent inflammation development. (Fig. 2, 3)

In samples of the 2nd group, the number of hard microparticles was significantly reduced; the integrity of enamel prisms at the preparation interface was preserved. Significant fragments of chipped dental tissue were not observed; single dust fragments with a diameter up to 1 μm were present. At the same time, dentin surface, in general, was similar to naive dentin (Fig. 4a), the chemical composition of the enamel was characterized by a 20% higher fluorine level against a 9% decrease in calcium content (Fig. 4b, Table 3).

50% processing of the enamel in the 2nd control group made it possible to carefully examine the microstructure of dental tissue, identify shortcomings of traditional preparation technique and perform a micro X-ray structural analysis of enamel minerals (Fig. 5, Table 3).

A quantitative analysis of the chemical elements in the enamel of the 2nd control group showed that after finish the processing content of the calcium in dental enamel is significantly lower than in the enamel prepared by the traditional method. These data suggest the absence of post preparation hypersensitivity at preparation interface in the 2nd control group (Tables 2, 3). The maximum concentration of fluorine F_Ka 0,14-049; phosphorus P_Ka 14,66-17,24 and calcium Ca_Ka 39,73-43,29 (mass fractions, %) in the studied samples of dental tissue significantly varied depending on the method of preparation.

Table 1: Chemical composition of dentin minerals (F, P, Ca) in the 1st control group, the mass fraction (area 035)

#	Element	(KeV)	mass, %	Error, %
1	F	0.677	0.32	0.49
2	P	2.013	14.66	0.24
3	Ca	3.690	39.73	0.43
4	Other elements		45.29	0.38
	Total		100.00	

Table 2: Chemical composition of enamel minerals in the 1st control group (area 034)

#	Element	(KeV)	mass, %	Error, %
1	F	0.677	0.39	0.46
2	P	2.013	17.24	0.22
3	Ca	3.690	43.29	0.40
4	Other elements		39.08	0.36
	Total		100.00	

Table 3: Chemical composition of enamel minerals (F, P, Ca) in the 2nd control group (area 037)

#	Element	(KeV)	mass, %	Error, %
1	F	0.677	0.49	0.35
2	P	2.013	16.04	0.17
3	Ca	3.690	40.72	0.32
4	Other elements		42.75	0.28
	Total		100.00	

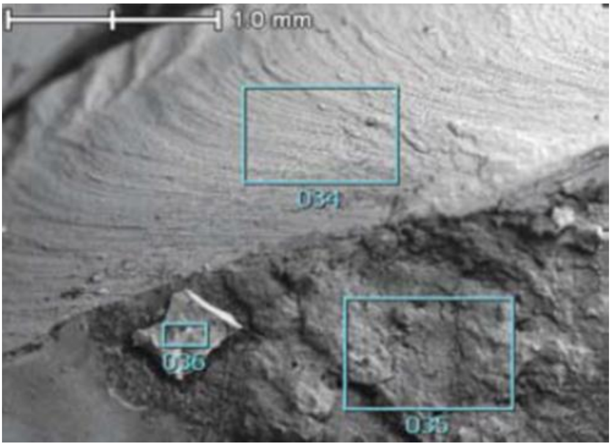

Figure 1a: SEM X120. The area of the dentine-enamel interface. Microanalysis of chemical composition was performed in the area of enamel (034) and dentin (035) surface

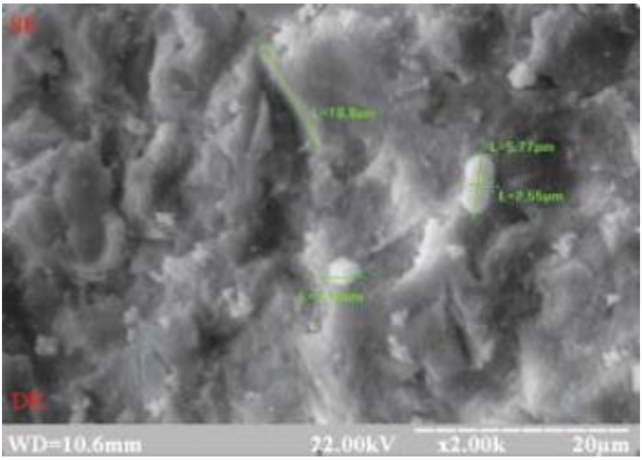

Figure 1b: SEM X2000. Enamel area after traditional preparation with a large number of microparticles of dental hard tissue

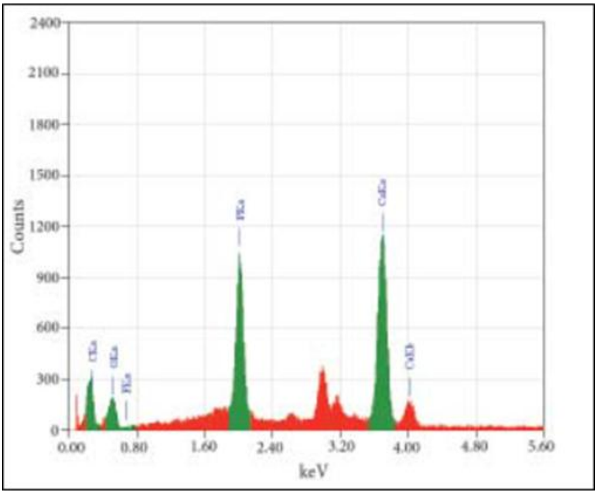

Figure 2: The characteristic spectrum of dentin minerals in the 1st control group (area 035)

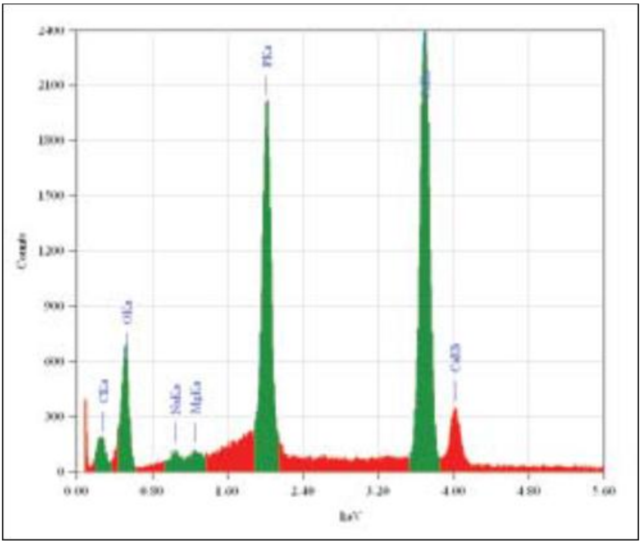

Figure 3: The characteristic spectrum of dentin minerals in the 1st control group (area 034)

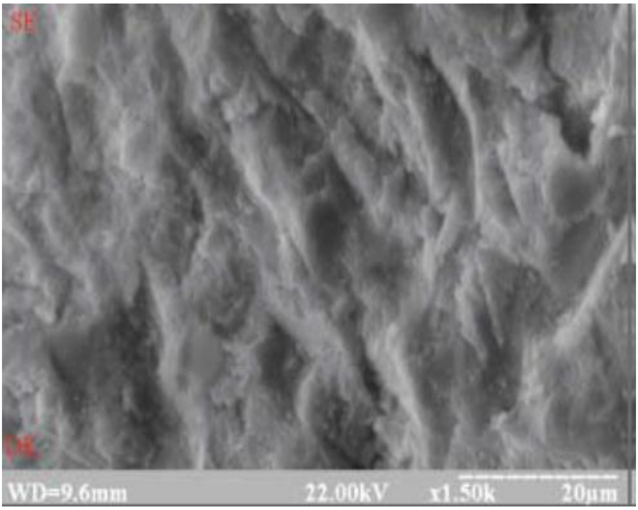

Figure 4a: SEM x1500. Dentin area after treatment with Sandman Futura device

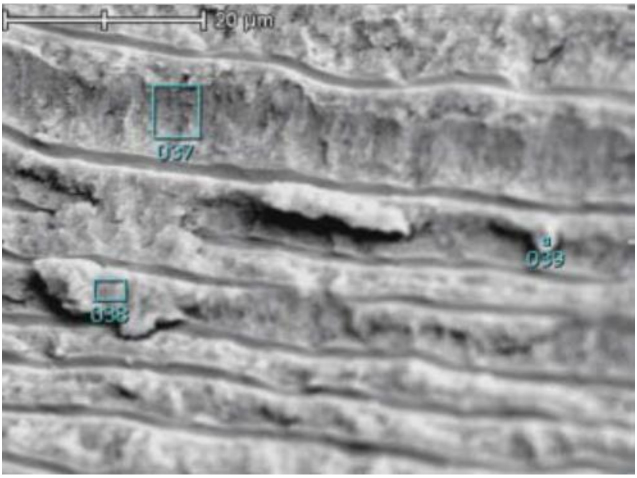

Figure 4b: SEM x1500. Microfractogram of the enamel of the 2nd control group

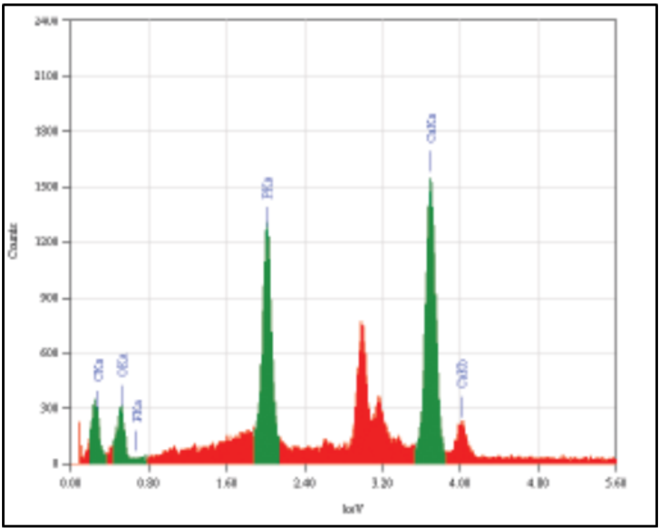

Figure 5: The characteristic spectrum of dentin minerals in the 2nd control group (area 037)

5. CONCLUSIONS

Electron microscopic examination of dentin showed that air-abrasive treatment led to more complete removal of the smear layer leaving open dentinal tubules. The results of enamel X-ray microanalysis confirmed that the content of the chemical elements F, P, Ca in healthy dental tissue is within the given ratio, but it significantly depends on the preparation technique. The air abrasion system used in the 2nd control group conducted more gentle preparation of enamel and dentin for bonding due to the preservation of enamel prisms (vital pulp) integrity at the preparation interface and improved of adhesive properties of the treated surface.

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