Scanning Electron Microscopy

Khaskhanova L.M.¹*, Razumova S.N.², Serebrov D.M.¹, Gureva Z.A.¹, Vetchinkin A.V.¹, Rebrii A.V.¹, Bait Said O.M.H.¹

1. Department of Propaedeutics of Dental Diseases, Medical Institute.

Abstract

This study compared two protocols. The protocol with liquid antiseptic showed a deeper penetration of adhesive material into the dentine tubules which indicates that the adhesion of composite material to the tooth tissues much stronger with the use of liquid antiseptic compared to the protocol where it is not used.

Keywords: Adhesive composite material, adhesive strength.

Received date: 18 December 2021
Accept date: 14 February 2022

Introduction

According to World Health Organization (WHO) dental caries currently remains one of the urgent medical problems in most countries ¹, 4, 5. This statement based on the results of scientific researches around the world ², 3. Dental caries treatment is carried out with the excision of irreversibly altered tooth tissues followed by replacement of the defect with sealing material. Sealing allows not only restore the tooth shape but also its function as a chewing organ. In dental practice composite sealing materials are used for dental caries treatment and increasingly replace other materials ⁶, ⁷, ⁸. Composite materials have problems related to marginal fit of the seal and tooth tissue. Therefore studies are being conducted to change the physical and chemical properties of composite materials which significantly reduce the percentage of complications in the treatment of caries. Dental sealing methods in the treatment of caries have to use of an adhesive system that provides better adhesion of the sealing material to the walls of prepared cavity ⁷, ⁹. However there is currently no data on the qualitative and quantitative penetration of bonding into the hard tooth tissues and optimization of the protocol. Bonding systems effectiveness evaluation is modern and relevant in treatment of dental caries and its complications.

Aim: Increase the treatment effectiveness of dental caries and its complications by optimizing the adhesive protocol.

Materials and methods

Twenty removed molars for orthodontic indications were used for research. In preparation for the experiment the teeth were divided into 2 equal groups according to the number of adhesive protocols used. Cavities were formed according to Black’s Classification Class I with a size of 6 x 5 mm. The study used: etching gel "TRAVLIN" containing 35% orthophosphoric acid, antiseptic liquid (TechnoDent, Russia), ⁵th-generation adhesive "RESTORIN" (TechnoDent, Russia). The adhesive consists of dimethacrylate oligomers (Wis-GMA, TEGDMA, etc.), colloidal filler, modifiers, polymerization activators, stabilizers, solvents, sealing composite material Estelite Asteria. The formed cavities of 10 teeth in group I were treated according to the instructions (Protocol No. 1): an etching gel (35% orthophosphoric acid) was applied and after 15 seconds it was washed off with water, dried with compressed air for 10 seconds and then an adhesive was applied to the cavity and rubbed into the cavity walls for 15 seconds, dried for 10 seconds, photopolymerized for 20 seconds. The formed cavities of 10 teeth in group II were treated according to Protocol No. 2 with antiseptic liquid: an etching gel containing 35% orthophosphoric acid was applied for 15 seconds, washed off with water, dried with compressed air for 10 seconds and prepared cavity was treated...
with an antiseptic liquid for 15 seconds. After that an adhesive was applied, rubbed into the walls and bottom of the cavity for 20 seconds, dried for 10 seconds, photopolymerized for 20 seconds. After that all the teeth of both groups were sawed on a grinding machine with a cooling diamond disc into two halves in the sagittal direction. Next cutting was carried out on a precision cutting machine Presi Mecatome T201 with a cutting disc Met Disc-T based on Al₂O₃, cut thickness was 0.8 mm, disk rotation speed was 3600 rpm, cutting speed 0.1 mm/sec. After cutting the samples were cleaned from the remnants of lubricating and cooling liquid (water with surfactants) and other particles with 99.9% ethyl alcohol and compressed air, placed in individual plastic bags with a Ziplock latch (Figure 1) and sent to the scanning electron microscopy (SEM). It was carried out on the basis of the Technological Institute of Superhard and New Carbon Materials. The principle of scanning electron microscopy: an electron beam passes line-by-line across the entire scanning material and detector (located nearby) simultaneously counts the number of electrons trapped in it. A picture is built point-by-point based on the signal from the detector: the more electrons the detector has caught at a certain point of time the brighter dot in the picture corresponding to this point of time (Figure 1).

The width of electron beam is 20-40 nanometers which make it possible to achieve large magnifications and visualize the smallest elements of the surface relief.

Results

The study results showed the average value of penetration depth into the dentine tubules of the RESTORIN adhesive introduced into the cavity strictly according to the manual (Protocol No. 1) was 20.665 [19.55; 24.56] nm (Figure 2).

The average value of penetration depth into the dentine tubules of the RESTORIN adhesive introduced into the cavity according to Protocol No. 2 using an antiseptic liquid is 25.062 [21.67; 27.56] nm (Figure 3).

Note: Differences between protocols are statistically significant (p≤0.000377).
The antiseptic liquid contains 2% chlorhexidine compared to the protocol where it is not used.

The penetration depth into the dentine tubules of the adhesive material introduced into the cavity according to the Protocol using antiseptic liquid is 1.2 times greater than the penetration depth into the dentine tubules of the adhesive material introduced into the cavity according to Protocol No. 1 (Figure 4).

Discussion

Despite the development of modern systems and protocols for the prevention of dental diseases, the incidence of dental caries in population is at a fairly high level. The most common form of caries treatment is the removal of caries-affected tissues and subsequent composite restoration.

The reliability of composite restoration depends on many factors. Properly selected restoration material, which is selected based on the initial clinical case and the functionality of a given tooth or group of teeth; and the choice of a correct generation of adhesive system and adhesive preparation of hard tooth tissues; and the right occlusal correction using articulation paper of different thickness and the corresponding protocol.

Special attention should be paid to the elimination of the lubricated layer from the surface of the tooth hard tissues. This is very important, because the lubricated layer formed on the tooth hard tissues after preparation and representing dental dust, solid particles, microorganisms and the remnants of their vital activity prevents or makes impossible the deep penetration of adhesive systems into the dentine tubules and the formation of interprismal connections. Proper removal of the lubricated layer by applying orthophosphoric acid according to the method of total etching of hard tooth tissues allows to achieve maximum adhesion of the composite material. But the subsequent drying of the tooth hard tissues leads to collagen fibers collapse which largely prevents penetration of adhesive into the dentine tubules.

The adhesive protocol using antiseptic liquid showed a deeper penetration of the adhesive material into the tooth dentine tubules which indicates that the adhesion of the composite material to the tooth tissues will be 1.2 times stronger by using antiseptic liquid compared to the protocol where it is not used. The antiseptic liquid contains 2% chlorhexidine bigluconate which is an antiseptic that actively suppresses anaerobic flora as well as gram-positive and gram-negative bacteria. The easily evaporating liquid base reduces the surface tension coefficient and promotes deep penetration of the antiseptic into the dentine tubules. As a result of the conducted research it can be concluded that the use of this adhesive protocol with the use of antiseptic liquid will increase the efficiency of connecting composite filling material with tooth tissues and reduce the percentage of complications. Additionally, as SEM-EDAX is heavily dependent upon sample preparation, variation in polishing or sample tilt could overshadow any differences in the mineral content. The variable pressure scanning electron microscopy (VPSEM) offers the most comprehensive representation of bacterial biofilm morphology by avoiding the dehydration process and high chamber vacuum.

Conclusions

The protocol with liquid antiseptic showed a deeper penetration of adhesive material into the dentine tubules which indicates that the adhesion of composite material to the tooth tissues much stronger with the use of liquid antiseptic compared to the protocol where it is not used.

Declaration of Interest

The authors report no conflict of interest.

References


Figure 4


