Comparative Characteristics of Physical and Mechanical Properties of Adhesive Systems

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Abstract

This study compared two composite materials TechnoDent (Russia) and 3M ESPE (USA) for their adhesive strength. TechnoDent (Russia) contains dimethacrylate oligomers (Bis-GMA, TEGDMA, etc.), colloid filler, modifiers, polymerization activators, stabilizers, solvents. 3M ESPE (USA) contains Bis-GMA, HEMA, dimethacrylates, ethanol, water, photoinitiator, methacrylate copolymer of polyacrylic and itaconic acids, silicon filler.

The average value of the adhesive strength in TechnoDent (Russia) was 20.4 [18.4; 22.4] and for 3M ESPE (USA) the indicator corresponds to the value of 21.6 [19.5; 23.7]. Thus adhesive strength of composite materials TechnoDent (Russia) and 3M ESPE (USA) have no statistically significant differences (p=0.19747).

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Introduction

Currently composites occupy a leading position among all restoration materials. First of all, this is due to their high aesthetic and strength characteristics.[1,2,3]

According to various authors 30-70% of all restoration replacements occur initially due to violations of marginal permeability.[1,4] The formation of a dense, stable connection between the filling material and the hard tissues of the tooth depends mainly on the adhesive systems used, which have become firmly established in dental practice. They provide a reliable edge fit of the fillings, increase the adhesion force of the tooth hard tissues and the filling material, prevent the penetration of microorganisms into the tooth pulp and contribute to the reduction of hyperesthesia.[5] Currently, composite materials of light and chemical curing are widely used in practical dentistry for the restoration of tooth hard tissues in dental caries and the presence of non-carious lesions.[3,5,6,7] The introduction of high-quality restoration materials and modern adhesive systems into dental practice has significantly reduced the need for extensive preparation of tooth hard tissues.[4,5] Indications of their use have expanded, from selective restoration of a separate fragment of an anterior tooth to complete restoration of chewing teeth. The use of adhesive restoration strengthens the preserved enamel and dentin making them more resistant to destruction.[2,4] With the advent of new adhesive systems of the V generation with significantly improved chemical and biomechanical properties dentists have received a wider choice in solving and carrying out aesthetic work. Also increased reliability with faster application as well as a reduction in the number of components.[8,9,10]

Aim: Adhesive strength assessment of the restoration composite material joint with the tooth hard tissues depending on the adhesive system.

Materials and methods

The 20 removed teeth (molars and premolars) were used for orthodontic indications. In preparation for the experiment the teeth were randomly divided into 2 equal groups according to the number of adhesive systems used. Each tooth was sawed on a grinding machine with a cooled diamond disc into two halves in the sagittal direction. Then each half was mounted into the block with self-hardening plastic in such a way that the cutting plane of the working

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surface of the tooth for testing was open and located on the surface of the block. The working surface of the cut was sanded, washed with water, dried with filter paper and an adhesive system was applied according to the manufacturer's instructions. The study used adhesives of the V generation ("single-bottle") Adhesive No. 1 (TechnoDent, Russia. Composition: Dimethacrylate oligomers (Bis-GMA, TEGDMA, etc.), colloid filler, modifiers, polymerization activators, stabilizers, solvents. Processing method: application of etching gel (35% orthophosphoric acid) for 15 seconds, rinsing with water, drying with compressed air for 10 seconds, application of adhesive and rubbing for 15 seconds, drying for 10 seconds, photopolymerization for 20 seconds. Adhesive No. 2 (3M ESPE, USA. Composition: Bis-GMA, HEMA, dimethacrylates, ethanol, water, photoinitiator, methacrylate copolymer of polyacrylic and itaconic acids, silicon filler. Processing method: application of etching gel (35% orthophosphoric acid) for 15 seconds, rinsing with water, drying with compressed air for 10 seconds, application of adhesive and rubbing for 20 seconds, drying for 10 seconds, photopolymerization for 20 seconds. After curing of the adhesive a steel detachable cylindrical shape with a height of 3 mm and a diameter of the forming hole of 3 mm was installed on its surface.

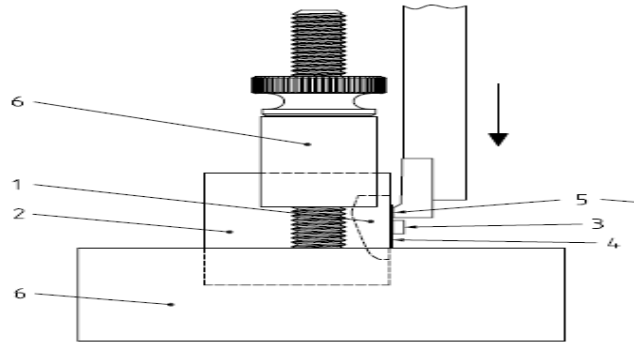

Figure 1. Schematic representation of adhesive shear strength tests: 1 - tooth; 2 - block with a tooth sample in self-hardening plastic; 3 - composite material column; 4 - cured adhesive; 5 - knife transmitting shear force; 6- test clamp.

The mold was filled with a composite paste and cured for 30 seconds. After 10 minutes the mold was removed and sample of the composite tooth adhesive compound was placed in distilled water and kept in a thermostat at a temperature of (37.0+1.0) °C for 24 hours. Tests of the adhesive shear strength of the prepared samples were carried out on a universal testing machine "SYNTHEZ 5" (Figure 1) with a traverse speed of 5 mm/min, according to State Standard GOST R 56924-2016 (Item 7.15).

Results

The adhesive strength with tooth tissues joint was determined as the shear strength of a cylindrical sample of composite material relative to the surface of tooth tissues. The test results are presented in Table 1.

Material	MPa, (M±s)
Adhesive No. 1	20.4±2
Adhesive No. 2	21.6±2.1**

Table 1. Adhesive strength of the composite joint with tooth tissues in various adhesive systems.
**Note: Adhesive No. 1 and adhesive No. 2 have no statistically significant differences (p=0.19747).

The average value of the adhesive strength of adhesive No. 1 in the composite compound with tooth tissues was 20.4 [18.4; 22.4]. For adhesive No. 2 the indicator corresponds to the value of 21.6 [19.5; 23.7]. Imaging with a 4-fold increase in the rupture site revealed destruction along the border of the tooth tissue-adhesive in most samples. The adhesive strength of adhesive No. 1 exceeds the requirements of State Standard GOST R 56924-2016 by 2.9 times and for adhesive No. 2 - by 3.1 times. All tested adhesive samples have sufficiently high adhesion to the hard tissues of the tooth corresponding to the requirements of State Standard GOST R 56924-2016 (at least 7 MPa). The data is shown in Figure 2.

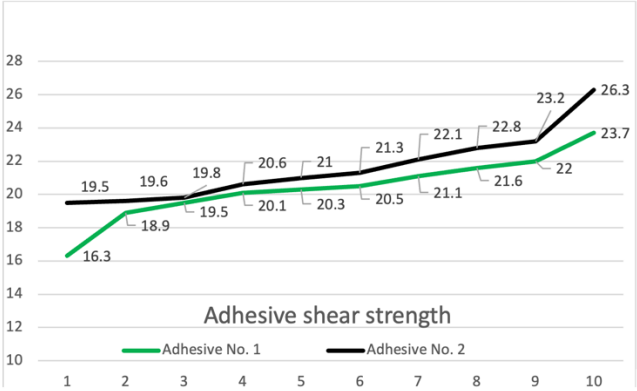

Figure 2. The data is shown in Figure.

Discussion

The mechanism of the studied adhesive systems works on the principle of deep penetration of adhesive materials into the dentinal tubules and space between the prisms. The straightened and well moistened collagen fibers which are located in the dentinal tubules contribute to the good penetration of the adhesive material into the dentinal tubules. After penetration of the adhesive material into the dentinal tubules and subsequent polymerization an inhibited layer forms on the surface of the hard tissues of the tooth which provides a strong bond due to active radicals with the composite material which will later be applied. On the other hand the deep penetration of the adhesive material into the dentinal tubules and the subsequent polymerization of the adhesive ensures stability and retention of the composite restoration in the tooth cavity with the resulting shrinkage stress. After preparation of the tooth surface in various types of dental treatment a smashed layer is formed consisting mainly of dust-like remnants of hard tooth tissues, products of the caries process, blood, saliva, etc. As a result of the formation of this layer the dentinal tubules and partially space between the prisms are blocked. This factor leads to the fact that adhesive material is unable to penetrate in dentinal tubules[1,2]. As a result the adhesive material polymerizes on the surface of the hard tissues of the tooth without penetrating into the dentinal tubules. The resulting shrinkage stress after application and polymerization of the composite material can tear the adhesive material from the surface of the hard tissues of the tooth. This in some cases may lead to loss of whole system. When etching gel is applied to dentin an orthophosphoric acid forms acid phosphates with calcium of dentin and the smashed layer which helps to remove the smashed layer, open the dentinal tubules and transforms the surface for providing high infiltration of the adhesive resin with the formation of a new structure which is a polymer matrix reinforced with collagen fibers forming a hybrid layer[1,2.] It is important to note that the preparation of the tooth tissue surface before adhesive treatment is of great importance and affects the quality and long-term restoration. V generation adhesives required etching have demonstrated high adhesion to tooth tissues. The investigated adhesive No. 1 exceeds the requirements of State Standard GOST R 56924-2016 almost 3 times in adhesive fixation strength and is not inferior in this parameter to adhesive No.2. Imaging with a 4-fold increase in the rupture site of the test samples and the number of tests performed on twenty removed teeth ensures the reliability of obtained results.

Thus the study experimentally confirms that in case of tooth hard tissue correct preparation for fixation the adhesive No. 1 is not inferior compare to adhesive No. 2 in strength of adhesion. Based on experimental data experts suggest that adhesive composite materials should have high color stability, applied with precoated technique and be orthodontic.[12,13,14]

Conclusions

Adhesive strength of composite material Adhesive No.1 and Adhesive No.2 have no statistically significant differences (p=0.19747).

Declaration of Interest

The authors report no conflict of interest.

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