MEDICAL SCIENCES

ASSESSMENT OF THE QUALITY OF RESTORATION OF DAMAGED TEETH USING MODERN METHODS

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https://doi.org/10.5281/zenodo.13768688

To date, a large number of intracanal and parapulpal pin systems have been developed that serve as support in orthopedic structures [2, 5]. The use of pins is clinically justified both in the area of chewing teeth, when the coronal part of the tooth is destroyed by 2/3 or more, and in the frontal region, where there are morphological and functional prerequisites associated with a limited volume of the hard substance of the tooth and significant bending loads. However, the use of these structures is associated with the risk of numerous complications. Intracanal metal pins easily corrode and cause oblique and longitudinal fractures of tooth roots that cannot be further restored. Parapulpal pins lead to cracks in the hard tissues of the tooth and also pose a danger to the pulp [8]. Periapical changes are more often observed in teeth restored with post structures than in endodontically treated teeth without supporting elements. The presence of a rigid rod in the root of the tooth leads to a redistribution of stresses that arise during chewing loads in the root-periodontium-alveolar wall system, with their increase in the apical part of the root. This fact is confirmed by modern studies using the finite element method [4]. To eliminate these shortcomings, silanized, elastic fiberglass pins, such as LuxaPost (DMG, Germany), are currently being developed, making it possible to create a single complex from the residual substrate, Corecomposite, which simultaneously serves as a material for fixation and the pin itself. At the same time, the improvement of direct restoration technologies, when the level of adhesion of modern filling materials has reached 50 MPa or more, i.e. the level of forces connecting healthy dentin and enamel, makes it possible to restore damaged teeth without pins [7]. The range of tools used is constantly expanding. The first step in this direction is the division of composites into posterior and anterior, which differ in their properties. In the last decade, Core-composites have appeared that make it possible to restore a tooth stump after endodontic treatment, with a significant amount of loss of hard substance. In pinless restoration, the composite is introduced into the orifices of the root canal to a depth of 3-4 mm. If we take into account the possible height of the residual walls, then the question arises about the quality of curing of the photopolymerizing components of adhesive systems and replacement materials in this area. One of the possible ways to solve this problem, proposed by manufacturers, is to use a dual-curing mechanism and introduce an additional activator. An example is the LuxaBond adhesive system (DMG, Germany), which makes it possible to guarantee high-quality polymerization regardless of the thickness of the composite layer, the distance from the light source to the surface to be cured, and the intensity of the light flux. The purpose of this study was to compare different methods of adhesive reconstruction of decayed teeth.

The subjects of the study were 40 extracted noncarious human molars in a 0.5% chloramine-T solution at 4°C, which were used for a month after extraction. On the extracted teeth, the cusps were sawed off until the dentin surface was exposed without enamel residues in the fissure area. Using a grinding disc with a constant supply of water, the crown was brought to a diameter of 8.5-9 mm. In this way, the situation of restoring a tooth stump without residual walls was simulated, respectively, without the influence of the cavity configuration factor - the C-factor. The second restoration option was the preparation of cavities of the 1st class according to Black (4x4 mm). The samples were divided into 12 groups of 2-3 teeth each. The filling materials used were Filtek Z 250 (3M Espe), Ecusit (DMG), LuxaCore Z (DMG) in combination with one-component adhesive systems Adper Single Bond (3M Espe), Teco (DMG) and a multi-component adhesive system LuxaBond (DMG). Photopolymerization of all light-curing materials was carried out with a halogen lamp (Translux CL, Heraeus Kulzer, Dormagen). Curing of each increment was carried out by direct illumination of the composite surface for 40 s. Etchant gel (3M Espe) was used for acid etching. The dentin surface was etched for 15 s. The adhesion between the composite and the dentin surface was tested using micro tensile testing (μTBS). 24 hours after core reconstruction, the teeth were sawed with a water-cooled diamond saw (Isomet®, Buehler, Lake Bluff, USA) into 4–5 sections with a thickness of 0.5–0.7 mm. The sections were sawn in the direction of the longitudinal axis of the tooth. Thus, the resulting samples had the shape of sticks consisting of dentin and composite. The tensile strength between dentin and composite was measured using a universal testing machine (Zwicki—Modell Z/2.5 Ulm, Germany) with a feed speed of 1 mm/min [6]. The surface topography of specimens subjected to microtensile testing and selected for microscopic examination was examined using a scanning electron microscope (SEM; Leitz® ISI 50, Akashi, Tokio, Japan and Tiffmess®—Software V1.9, Universität

Erlangen). The samples were dehydrated and gold-plated using a special device (Balzers® SCD 40, Balzers, Liechtenstein). Statistical processing of the material was carried out using the Kolmogorov-Smirnov test and one-way analysis of variance. Multigroup comparisons were made using the Games-Howell test. Student's t test was used to assess differences between the two groups. Differences were accepted as statistically significant at $p \leq 0.05$. Preparation of samples for the restoration of a tooth stump using various techniques for applying filling material. The application of the composite was carried out in various ways (Table 1). In class 1 cavities, the composite was applied both in one portion (Bulk technique) and in three horizontal layers. In the remaining groups, restoration was carried out by simulating the clinical situation in the complete absence of the crown part of the tooth, i.e., without the influence of the cavity configuration factor. To improve adhesion, the application of filling material using a modified technique was used: the first portion of the composite was applied to ¼ of the surface of the dentin area with a layer thickness of 1.5 mm. After light curing of the first increment, the second portion of the composite was applied to the second quarter of the surface, followed by photopolymerization. The third and fourth portions of the composite were applied and cured in a similar manner. The possibility of improving the adhesion of the replacement material by applying a thin layer of flowable composite, the so-called lining technique, was also investigated. Results and discussion Pinless restoration methods make it possible to achieve high levels of adhesion of replacement materials to the hard tissues of the tooth. However, adhesive forces vary significantly depending on both the material and adhesive agent used, and the technique of applying the composite. The range of adhesion indicators is from 9 to 60 MPa (Table 2). In groups restored under the influence of the cavity configuration factor, when polymerization stress has a maximum destructive effect on the joint zone, the highest results were obtained using the Teco adhesive system and Ecusit restoration material

The bond zone when using LuxaBond and Ecusit turned out to be the least stable. Adhesion indicators did not exceed 9.86 MPa, 81% of samples did not pass the tensile test. The modern Core-composite, when applied in one portion, demonstrated low adhesion rates (9.4 MPa) with 71% of lost samples. The automatic mixing system of LuxaCore Z allows you to sequentially add 3 portions of the composite with intermediate illumination without changing the cannula. At the same time, the solidity of the restoration, just like with conventional composites, is guaranteed by a layer oxidized with oxygen. Crushing the composite into 3 portions made it possible to increase the adhesion forces with hard tooth tissues by 2.7 times. In the absence of the influence of the C-factor, when the situation of building up a stump with virtually no residual composite walls is simulated, the application technique is also of great importance for the quality of restoration and adhesion strength. In these conditions, the use of the Bulk technique is possible. The adhesion of Corecomposite to the leveled dentin surface increases to 48.14 MPa. A modified technique for adding a composite makes it possible to minimize the negative impact of polymerization stress, which occurs both in a closed cavity and on a flat surface of hard tissues [1]. It is based on the following principles: • the determining factor is not the thickness of the applied layer, but the surface area on which the composite is applied; • for subsequent portions, it is necessary that the contact area with the already cured portion of the composite be minimal and, if possible, this contact should be avoided. When using a combination of the LuxaBond-Ecusit and Adper Single Bond-Filtek Z 250 systems, the adhesion forces increase by 4.7 and 1.8 times, respectively, compared to class 1 cavities. At the same time, the use of the 5th generation Teco adhesive in the absence of C-factor revealed a 2-fold decrease in adhesion.

The addition of a flowable composite can be considered as creating a “shock absorber” of polymerization stress [3]. Application and curing of a thin layer of flowable composite directly after the lining agent allowed for increased adhesion forces only when LuxaBond was used in combination with Ecusit composite. Individual samples that underwent tensile testing in a testing machine were subjected to electron microscopic examination. In the overview image of the dentinal part of the sample when LuxaBond and LuxaCore Z were used, the remains of the composite are clearly visible in the upper left sector, which indicates a combined cohesive-adhesive type of fracture. This illustrates the high stability of the joint zone, confirmed by the micro tensile test results. Dentin surface when using the LuxaBond adhesive system

and the Core composite remains covered with a hybrid layer almost throughout. Only minor areas of free surface are detected. At higher resolution, closed lumens of the dentinal tubules are observed. Teco's fifth generation adhesive system also demonstrated fairly complete dentin hybridization. Only in the deep areas of the cavity were surface fragments identified where, apparently, the adhesive mediator was insufficiently polymerized and, during the tensile test, partial release of polymer strands from the lumens of the dentinal tubules occurred. Thus, pinless restoration with adhesively fixed replacement materials can be considered an effective method for restoring damaged teeth. However, the negative point is the high sensitivity of the joint zone to the damaging effects of polymerization shrinkage of the composite. It should be noted that modern Core materials have shown high efficiency both in terms of material adhesion and in terms of subsequent processing of the stump. For example, LuxaCore Z has similar mechanical properties to dentin. This avoids the phenomenon typical of conventional composites, such as immersion of a rotating bur into the material during grinding, which leads to the removal of more composite than the hard substance of the tooth. At the same time, the color and transparency of the material differ from dentin and enamel, facilitating the formation of a ledge within hard tissues. Adhesive mediators generally seal the bonding zone well; only in the deepest areas was the polymer resin not fully cured. The inclusion of a dual curing mechanism when using an additional activator in the LuxaBond bonding system allows you to avoid this negative phenomenon.

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