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Research Article

The Experimental Substantiation of the Use of Various Adhesive Protocols for Dental Fillings

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Received: December 17, 2024; **Published:** January 30, 2024

Abstract

Introduction and Aim: Recurrent caries remains a significant challenge in restorative dentistry, with the quality of adhesion between composite materials and dentin playing a crucial role in the longevity of dental fillings. The development of adhesive systems and protocols has aimed to improve the bond strength and reduce postoperative sensitivity. This study aimed to evaluate the adhesion quality of composite restorative materials to dentin using different adhesive preparation techniques for both vital and non-vital teeth.

Methods: This was a laboratory-based experimental study involving 60 extracted teeth from patients aged 18 to 55 years. The teeth were divided into four groups: two control groups (vital and non-vital teeth restored with a standard adhesive protocol) and two experimental groups (vital and non-vital teeth restored using a 5th-generation adhesive system with additional post-acid treatment). The adhesion quality was evaluated using scanning electron microscopy to assess the marginal gaps between the composite material and dentin.

Results: The study found that marginal adaptation defects were observed in 100% of vital teeth in the control group, with a maximum gap of 34,056.28 nm. In contrast, the experimental groups showed significantly reduced marginal gaps, with the lowest observed gap in the group using post-acid treatment (7%). Statistical analysis revealed significant differences ($p < 0.05$) between the control and experimental groups, with the post-acid treatment protocol improving adhesion quality.

Conclusion: The study demonstrated that the use of a post-acid treatment protocol, involving ethanol and chlorhexidine, significantly improves the adhesion of composite restorative materials to dentin, especially in non-vital teeth. This approach may enhance the durability and stability of dental fillings, reducing the risk of postoperative sensitivity and improving treatment outcomes.

Keywords: *Dentin Adhesion; Composite Material; Adhesive System; Chlorhexidine; Scanning Electron Microscopy; Caries Prevention*

Introduction

Due to the high prevalence of recurrent caries, the development and improvement of methods for its prevention and the enhancement of treatment quality remain highly relevant. This can be achieved through the creation of new restorative materials and adhesive systems [1,2], as well as by improving the quality of the adhesive bond between composite materials and tooth dentin [3]. Enhancing the stability of adhesive materials can be accomplished by modernizing adhesive protocols.

Currently, scanning electron microscopy is widely used for analyzing adhesive dentin-polymer bonds. This method allows for the evaluation of the quality of the restorative material's adhesion to dentin by providing detailed surface topography of the sample under study.

Objective of Our Study

To assess the quality of adhesion of composite restorative materials to dentin using different adhesive preparation techniques for the hard tissues of vital and devitalized teeth.

Materials and Methods

The study utilized teeth extracted for medical reasons from patients aged 18 to 55 years. These teeth were randomly divided into four groups, each consisting of 15 teeth. Control groups 1 and 2 included vital teeth (Group 1) and devitalized teeth (Group 2) restored using composite material following a standard protocol with a 5th-generation adhesive system.

The experimental groups included vital teeth (Group 3) and devitalized teeth (Group 4) restored with composite material using a 5th-generation adhesive system along with additional post-acid treatment. This treatment involved sequential application of a 95% ethanol solution onto the moist tooth surface from a syringe, distributed continuously with an applicator for 60 seconds, followed by the application of a 2% chlorhexidine digluconate solution in the same manner for another 60 seconds. Before applying the nanofilled 5th-generation adhesive, the dentin was air-dried.

All teeth were cleaned and stored in a 0.1% thymol solution at 4°C for one month. Subsequently, a Class I cavity (according to Black's classification) with a depth of 4 mm and a width of 5 mm was prepared in each tooth. The treated teeth were then immersed in 0.09% NaCl solution at 35 - 40°C for 48 hours, followed by air drying for 24 hours.

For microscopic examination, longitudinal sections of the teeth, 1.5 - 2 mm thick, were prepared using a straight handpiece and a diamond separation disc. These sections were mounted on stubs and coated with gold using a BIO-RAD Microscience Division E 5000 M sputter coater (UK). The thickness of the gold layer was approximately 100 Å.

Electron microscopy of the samples was conducted using a TESCAN VEGA3 scanning electron microscope (Czech Republic) under the following conditions: accelerating voltage of 20 kV and a working distance of 14 - 16 mm. Measurements of the objects in the micrographs were performed using the built-in software of the electron microscope at ten control points in the area of contact between the dentin and the restorative material.

Two micrographs were used for measurements, captured in secondary electron mode: one showing the minimum discontinuity in the interface between the composite material and dentin, and the other showing the maximum discontinuity. Statistical analysis was conducted based on the principles of variation statistics, and the results were evaluated using Medstatistic software.

Results and Discussion

In this study, we examined one of the protocols for post-acid treatment of dentin during the restoration of teeth with composite materials. For dentin hybridization, 95% ethanol was used. Ethanol molecules, when applied to hydrophilic dentin, displace water molecules, making the dentin more hydrophobic and ensuring a uniform adhesive layer.

Table 1 presents the characteristics of marginal adaptation defects between the composite restorative material and dentin in the four groups of teeth.

An analysis of the results from the electron microscopy study revealed the following are discussed below.

Group	Frequency of Marginal Gaps (%)	Min Gap (nm)	Max Gap (nm)	Avg Gap (nm ± SD)
1	100%	2209.40	34056.28	8297.80 ± 644.34
2	55%	7855.67	19542.92	15486.67 ± 776.49
3	13%	2645.37	3968.06	3460.25 ± 347.51
4	7%	2088.10	4864.30	4411.00 ± 640.64

Table 1: *Comparative characteristics of marginal gaps in four tooth groups.*

Group 1: Marginal adaptation defects were observed in 100% of cases. Measurements of the gap between the dentin and the composite restorative material in the contact area showed a maximum separation of 34,056.28 nm and a minimum of 2,209.40 nm, with an average value of 8,297.80 ± 644.34 nm (Figure 1).

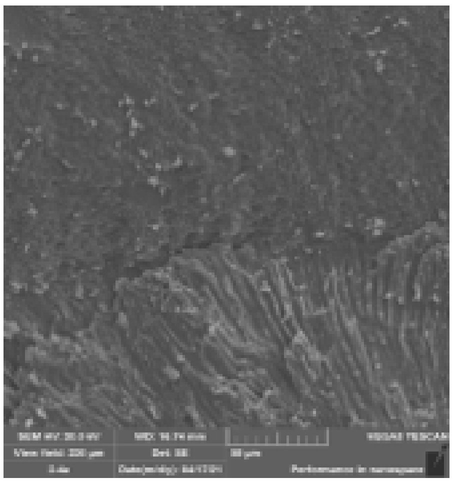

Figure 1: *Micrograph of tight dentin-filling adherence in group 1 (X 1160 magnification).*

Group 2: Marginal adaptation defects were observed in 55% of cases. Measurements in the contact defect zone revealed a maximum gap of 19,542.92 nm and a minimum of 7,855.67 nm, with an average value of 15,486.67 ± 776.49 nm (Figure 2).

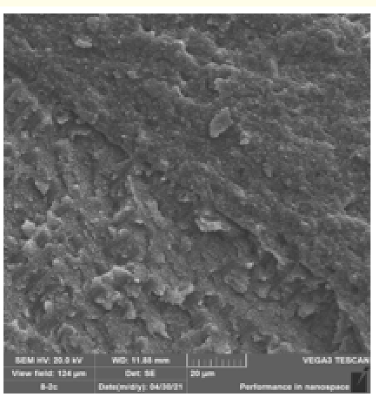

Figure 2: *Micrograph of dentin-filling adherence in group 2 (X 2040 magnification).*

Group 3: Marginal adaptation defects were observed in 13% of cases. The maximum separation between the composite material and dentin was 3,968.06 nm, the minimum was 2,645.37 nm, and the average value was 3,460.25 ± 347.51 nm (Figure 3).

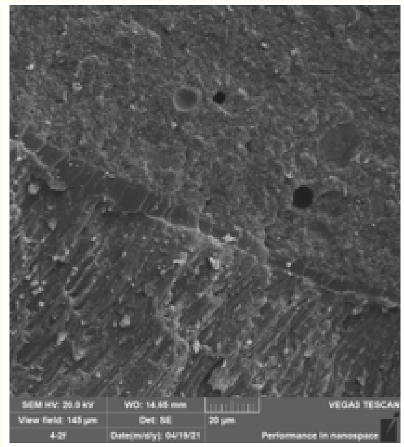

Figure 3: *Micrograph of adherence in group 3 (X 1750 magnification).*

Group 4: Marginal adaptation defects were observed in 7% of cases. The maximum gap between the composite material and dentin was 4,864.30 nm, the minimum was 2,088.10 nm, and the average value was 4,411.04 ± 640.64 nm (Figure 4).

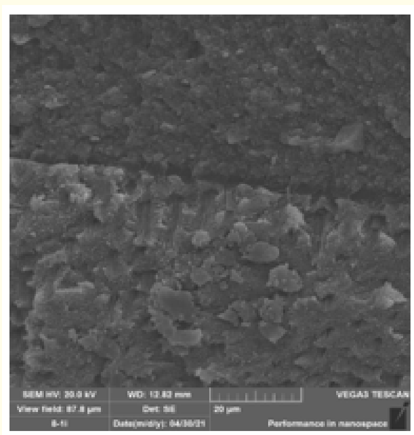

Figure 4: *Micrograph of adherence in group 4 (X 2890 magnification).*

The analysis of the results showed statistically significant differences ($p < 0.05$) in the separation values between the composite material and dentin when comparing groups 1 and 3, as well as groups 2 and 4. The lowest separation values were observed in the groups where additional post-acid treatment of the tooth was applied.

Conclusion

1. The quality of composite material adaptation to dentin significantly improves when using an adhesive protocol that includes the sequential application of 95% ethanol, 2% chlorhexidine digluconate, and a 5th-generation adhesive system following preliminary total etching of the tooth hard tissues. The gap between dentin and the composite filling material demonstrated a comparable difference in vital and non-vital teeth, averaging 3460.20 nm and 4411.00 nm, respectively.

2. The assessment of the quality of composite material adaptation in vital and non-vital teeth without additional post-acid dentin treatment using the proposed method revealed gaps of up to 34,056.28 nm. This may lead to postoperative sensitivity when the filling is subjected to mechanical load or temperature changes.

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Volume 14 Issue 2 February 2025