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Original Article

Influence of different endodontic irrigants on shear bond strength of composite resin to coronal dentin: An *in vitro* study

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ABSTRACT

Objectives: Endodontic irrigants are critical in root canal treatments, but their influence on the coronal dentin bond strength of composite restorations is a key concern for a favorable clinical prognosis. The present *in vitro* study explores the effect of different endodontic irrigants on shear bond strength of composite resin.

Material and Methods: Fifty permanent human mandibular molars were sectioned to expose coronal dentin and divided into five groups. Each group received a specific irrigant treatment before composite resin bonding. Shear bond strength was examined using Instron Universal testing machine, and statistical analysis was conducted using *post hoc* Tukey's test and analysis of variance.

Results: Group A (Saline) showed a mean shear bond strength of 18.5 Megapascal (MPa). Group B [sodium hypochlorite (NaOCl)] had mean shear bond strength of 15.2 MPa. Group C [Chlorhexidine (CHX) Gluconate] exhibited mean shear bond strength of 20.3 MPa. Group D ethylenediaminetetraacetic acid (EDTA) recorded mean shear bond strength of 14.8 MPa, while Group E [citric acid (CA)] had the highest mean shear bond strength at 22.7 MPa.

Conclusion: The type of endodontic irrigant used significantly affected the shear bond strength of composite restorations to coronal dentin. CHX gluconate and CA displayed superior bond strengths compared to Saline, NaOCl, and EDTA. This underscores the importance of irrigant selection in achieving successful composite restorations in endodontically treated teeth.

Keywords: Coronal dentin, Chlorhexidine gluconate, Citric acid, Endodontic irrigants, Shear bond strength

INTRODUCTION

Endodontic therapy, a common dental procedure, aims to remove infection, alleviate pain, and preserve the natural dentition.[1] Root canal treatment involves the use of various irrigants to disinfect the root canal system and subsequently preserve the infected tooth in oral cavity.[2] While the effectiveness of these irrigants in eradicating pathogens is well-established, their impact on the coronal dentin bond strength of composite restorations has garnered attention in recent years.

In the field of restorative dentistry, achieving strong and durable bonds between composite materials and dentin is crucial for the long-term success of restorations.[3] A compromised bond can lead to restoration failure, recurrent caries, and ultimately, tooth loss.[4] Therefore,

understanding how endodontic irrigants affect the bond strength at the coronal dentin-composite restoration interface is essential for improving clinical outcomes.

Several endodontic irrigants are commonly used, including sodium hypochlorite (NaOCl), chlorhexidine (CHX) gluconate, ethylenediaminetetraacetic acid (EDTA), and citric acid (CA). Each of these agents has unique properties, and their interactions with dentin can vary significantly. NaOCl, for example, is an effective antimicrobial agent but can negatively impact bond strength as it inhibits resin polymerization.[5] Conversely, CHX gluconate, a broad-spectrum antimicrobial agent, may offer benefits in terms of bond preservation.[6]

The present *in vitro* study aims to provide valuable insights into the influence of different endodontic irrigants on the shear bond strength of composite restorations to coronal dentin. By evaluating the performance of various irrigants, clinicians can make informed decisions when selecting irrigation protocols, potentially enhancing the longevity and success of restorative treatments.

In light of the aforementioned considerations, this research seeks to address the following question: What is the impact of various endodontic irrigants on the shear bond strength between composite restorations and coronal dentin? The findings of the investigation may contribute to improved clinical practices and better patient outcomes in the field of restorative and endodontic dentistry.

MATERIAL AND METHODS

Specimen preparation

Fifty human permanent mandibular molars (freshly extracted) with no visible caries or defects were selected for the present *in vitro* study. All tooth samples were stored in distilled water (Sadbhavna Chemicals, Gujarat, India) at room temperature, considered best storage media to prevent dehydration.[7] The crowns of the teeth were sectioned transversely at a level 2 mm above the cemento-enamel junction (CEJ) using a water-cooled diamond saw (Isomet, Buehler, Lake Bluff, IL, USA). The exposed surface of the coronal dentin was finished using 600-grit silicon carbide paper (John Oakey and Mohan Ltd., India) to produce a uniform surface for further experiment. Afterward, each tooth was mounted using pink autopolymerizing resin (Pyrex, India) 1 mm below from the CEJ using custom built cylindrical stainless steel molds (size 16 mm height and 12 mm diameter) [Figure 1].

Group allocation

Fifty teeth were randomly distributed among five experimental groups, each consisting of ten teeth:

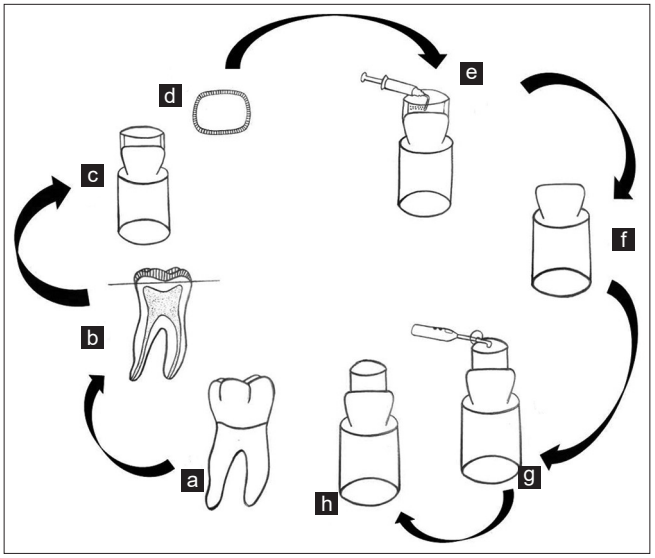

Figure 1: Schematic diagram of specimen preparation. (a) Permanent mandibular molar. (b) Horizontal sectioning beneath dentinoenamel junction. (c) Wax molding on the exposed coronal dentin. (d) Exposed coronal dentin surface from occlusal view. (e) Irrigants are filled in wax molds. (f) Wax molds de-assembled. (g) Composite resin cylinders are built on the treated dentin surface and light cured. (h) Prepared sample having bonded composite cylinder obtained after de-assembling the polyvinyl mold.

- Group A (saline): Teeth samples of this group received irrigation with 10 mL of sterile 0.9% normal saline (NS) solution (Nirlife, Gujarat, India) for 1 min.
- Group B (NaOCl): Teeth samples of this group received irrigation with 10 mL of 3% NaOCl (Vishal Dentocare Ltd., Gujarat, India) solution for 1 min.
- Group C (CHX Gluconate): Teeth samples of this group received irrigation with 10 mL of 2% CHX gluconate solution (Vishal Dentocare Ltd., Gujarat, India) for 1 min.
- Group D (EDTA): Teeth samples of this group received irrigation with 10 ml of 17% EDTA (CanalPro™ EDTA, ColteneWhaledent, USA) solution for 1 min.
- Group E (CA): Teeth samples of this group received irrigation with 10 ml of 20% CA solution (Ultradent™ CA, USA) for 1 min.

Irrigation protocol

In each group, wax mold (hollow wax blocks) of dimensions 2 mm height and 4 mm in diameter was made over the exposed coronal dentin surface to mimic the cavity of tooth and the respective irrigant was filled into these molds using disposable syringe (Dispo Van, India) as per group allocation. The irrigant was allowed to continue to be in contact with the dentin surface for 1 min to simulate the clinical irrigation protocol. Subsequently, the wax molds were removed and the

teeth were thoroughly rinsed with 20 mL of distilled water to remove residual irrigant and then blot-dried with absorbent paper.

Dentin surface preparation

After irrigation and rinsing, the coronal dentin surfaces of all teeth samples were etched with 37% phosphoric acid solution (3M ESPE, Germany) for 15 s, followed by thorough rinsing with distilled water and blot-drying.

Composite resin bonding

A self-etch adhesive system (3M ESPE, USA) was applied to the dentin surfaces according to the manufacturer's instructions. Composite resin (Filtex Z350, 3M ESPE, USA) cylinders (4 mm in diameter and 2 mm in height) were then built up in single increment using custom made polyvinyl molds (inner walls coated with non-reactant petroleum jelly) bonded on the treated dentin surfaces at room temperature and later light-curing was done for 20 s using a LED curing light kept 2 mm away from the surface with an output of 550 mW/cm^2 (Coltolux 2.5 Coltene, Switzerland) [Figure 1].

Shear bond strength testing

Shear bond strength testing was conducted using an Instron Universal testing machine (Model 3382, Instron Industries, USA), following the 2003 ISO Technical Specification #11405,[7] at a crosshead speed of 1 mm/min. A chisel-shaped steel blade was positioned at the interface between the composite resin and dentin, force was until failure occurred.[8] The force (in Newton) required for de-bond was recorded. Shear bond strength values were computed in Megapascals (MPa) by dividing the force (N) to the bonded surface area (πr^2).

Statistical analysis

One-way analysis of variance (ANOVA) was used to assess the shear bond strength values obtained, and *post hoc* Tukey's test was used for multiple comparisons. At $P < 0.05$, a significance level was established. The program Statistical Package for the Social Sciences 23 (IBM Corporation, Chicago) was used for the analysis.

RESULTS

For every experimental group, the shear bond strength values of composite restorations to coronal dentin are displayed in Table 1.

As results show [Table 1], each experimental group had a different mean shear bond strength value. Group C (CHX) exhibited the highest mean shear bond strength at 20.3 MPa, while Group D (EDTA) had the lowest mean shear bond strength at 14.8 MPa. The standard deviations indicate the degree of variability within each group.

One-way ANOVA was used to determine the statistical significance of these differences and *post hoc* Tukey's test for multiple comparisons was performed. The results of the statistical analysis are summarized in Table 2.

The results of the statistical analysis [Table 2] show that the shear bond strengths of the experimental groups differ in a way that is statistically significant. In comparison to NS (Group A), NaOCl (Group B), and EDTA (Group D), CHX (Group C) and CA (Group E) showed noticeably greater shear bond strengths.

These findings suggest that the shear bond strength of composite restorations to coronal dentin can be significantly influenced by endodontic irrigants used during endodontic therapy. In terms of bond strength, CHX and CA could be advantageous and NaOCl and EDTA might lead to weaker bonds.

DISCUSSION

The aim of the present *in vitro* study was to find out how various endodontic irrigants influenced the shear bond strength of composite restorations to coronal dentin. The findings underscored the significance of irrigant selection in restorative dentistry, since the shear bond strength values

Table 1: Shear bond strength values (in MPa) for each experimental group.

Experimental Group	Mean shear bond strength (MPa)	±SD
Group A (saline)	18.5	1.2
Group B (sodium hypochlorite)	15.2	0.9
Group C (Chlorhexidine Gluconate)	20.3	1.5
Group D (EDTA)	14.8	1.0
Group E (citric acid)	22.7	1.8

EDTA: Ethylenediaminetetraacetic acid, SD: Standard deviation, MPa: Megapascals

Table 2: Results of statistical analysis.

Comparison	*P*-value	Statistical significance
Group A versus Group B	0.013	Significant
Group A versus Group C	0.001	Significant
Group A versus Group D	0.002	Significant
Group A versus Group E	0.001	Significant
Group B versus Group C	0.007	Significant
Group B versus Group D	0.001	Significant
Group B versus Group E	0.001	Significant
Group C versus Group D	0.006	Significant
Group C versus Group E	0.001	Significant
Group D versus Group E	0.015	Significant

among the experimental groups varied significantly.

The higher shear bond strength noted in Group C (CHX) and Group E (CA) is noteworthy. CHX, a broad-spectrum antimicrobial agent, has been previously reported to have favorable effects on bond strength as it effectively inhibits matrix metalloproteinases enzyme collagenolytic activity present within the human dentin, thus has minimal impact on collagen structure, and hence, it improves bond longevity between adhesive and dentin.[1] Similarly, CA, when used as an endodontic irrigant, has demonstrated its ability to prevent denaturing of collagen, and thus, it maintains demineralized dentin collagen matrix structural integrity, leading to improved bond strength.[2] The results of the present *in vitro* investigation align with the previous literatures and bolster the use of CHX and CA as potential irrigants for preserving bond strength in restorative procedures.

Conversely, Group B (NaOCl) and Group D (EDTA) displayed lower shear bond strength values. NaOCl, a potent antimicrobial agent, has tissue-dissolving properties that can adversely affect collagen integrity and dentin structure. Moreover, it also inhibits composite resin polymerization, hence, potentially reduce the bond strength.[3] EDTA, on the other hand, is primarily used for smear layer removal but may weaken dentin by chelating calcium ions from hydroxyapatite crystals, causing major alteration in structure of dentin fibrils, thereby compromising the bond strength.[4] These findings are consistent with previous studies highlighting the negative impact of NaOCl and EDTA on bond strength.[5,6]

The role of NS (Group A) as an irrigant in maintaining moderate shear bond strength is of interest. While saline lacks the antimicrobial properties of the other irrigants studied, its relatively neutral nature may result in fewer adverse effects on dentin structure, thus preserving bond strength.[8]

Notably, the outcomes of the present *in vitro* investigation may not completely replicate clinical conditions as clinical scenarios involve various factors such as moisture control, patient-specific variables, and long-term challenges that can influence the bond strength of composite restorations.[9] However, the results of the present study show that the endodontic irrigants used during root canal therapy greatly influence the bond strength of composite resins used in tooth build after obturation. Hence, clinicians must keep in mind all the effects of different irrigating solutions on the dentin matrix that may subsequently affect the longevity of post-obturation core build-up restorations. Furthermore, the clinical applicability of these findings should be interpreted cautiously.

Limitations

It is important to note that these results are based on an *in vitro* study and may not fully replicate the clinical conditions. Moreover, results obtained in *in vitro* studies are affected by various parameters such level of clinical simulation achieved, age of teeth used, degree of dentin demineralization of bonded dentin surface, and type of bond strength test conducted. Further, research and clinical studies are required to validate and extrapolate the findings of the present *in vitro* study.

CONCLUSION

The shear bond strength of composite restorations to coronal dentin is greatly influenced by the choice of endodontic irrigants. CHX gluconate and CA appear to be promising irrigants for maintaining bond strength, while NaOCl and EDTA may pose challenges in this regard. Clinicians should carefully consider the choice of irrigant in restorative procedures to optimize clinical outcomes.

Ethical approval

The study protocol and design was approved by Institutional Research Development Committee (IRDC) via #SN1CE211220D dated 21-12-2020.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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