Original Article

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Dentistry Section

Comparison of Surface Roughness of Class V Cavity Preparation using Diamond Abrasive Point and Ultrasonic Tip and Measurement of Shear Bond Strength after Restoration with Composite Resin: An In-vitro Study

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ABSTRACT

Introduction: Non Carious Cervical Lesions (NCCLs) represent a prevalent dental condition characterised by the erosion of tooth structure at the cementoenamel junction without the involvement of dental caries. These lesions pose significant challenges due to their aesthetic impact, potential for dentinal hypersensitivity, plaque accumulation, pulpal complications and compromised structural integrity of the teeth. Tooth preparation traditionally uses diamond abrasive points and tungsten carbide burs for micromechanical adhesion. Newer methods, like ultrasonic tips, offer a more conservative approach, but limited research has compared their effects on bond strength, particularly in cervical cavity restorations with nanohybrid composites.

Aim: To compare the surface roughness of cervical cavity preparations utilising diamond abrasive points and ultrasonic tips, and to evaluate the shear bond strength of restorations with composite resin.

Materials and Methods: The present in-vitro comparative study was conducted in the Department of Conservative Dentistry and Endodontics, Guru Nanak Institute of Dental Sciences and Research, Panihati, Kolkata, West Bengal, India, from October 2023 to December 2023. The study included 52 freshly extracted maxillary 1st premolar teeth extracted for orthodontic reasons. These teeth were divided into two groups: Group-I (n=26) underwent surface preparation using a diamond abrasive point (No. 835-012, Piranha, SS White, USA), while Group-II (n=26) was prepared using an ultrasonic tip (Woodpecker G 20, Guilin Woodpecker, China). Teeth were cleaned, disinfected and stored in 0.1% thymol solution before being prepared with diamond abrasive points or ultrasonic tips, following which the specimens were restored using nanohybrid composite material (Solare X, GC Corporation, Japan). Surface roughness was assessed using a digital profilometer before the restoration, and the shear bond strength of repaired specimens was measured with a Universal Testing Machine. Statistical analysis was performed using GraphPad Prism, with independent samples t-tests applied to compare results between groups, and a significance level set at 5%.

Results: Group-I exhibited greater surface roughness (6.33±2.18 μm) compared to Group-II (4.91±1.57 μm). Group-I also showed higher shear bond strength (62±13 MPa) than Group-II (59.3±19.9 MPa), though this variation was not statistically significant (p-value=0.56).

Conclusion: Within the present study's limitations, diamond abrasive points created significantly greater surface roughness compared to ultrasonic tips. However, no statistically significant variations have been observed in shear bond strength among the two methods, suggesting that ultrasonic tips may be considered as an alternative to diamond abrasive points in clinical settings, avoiding their drawbacks while achieving adequate restoration retention.

Keywords: Erosion, Nanohybrid composites, Profilometer, Surface properties

INTRODUCTION

A NCCL refers to the erosion of tooth structure at the cementoenamel junction, which is typically not caused by dental caries [1]. Levitch LC et al., state that NCCLs are identified by the gradual and permanent loss of mineralised tooth structure at the cemento-enamel junction [2]. NCCLs cause aesthetic issues, dentinal hypersensitivity, plaque retention, pulpal involvement and tooth structural integrity problems. The prevalence of NCCLs ranges from 9.1% to 93.0% in South American populations [3] and 22.7% in the Indian population [4]. Restoring these lesions is challenging, involving isolation, tooth preparation, adhesion, insertion techniques, and finishing and polishing. Restoration failure primarily results from debonding. The recommended materials for restoring NCCLs are Glass Ionomer Cement (GICs), Resin-modified GICs (RMGICs), GIC/RMGIC liner bases combined with resin composite and composite resins. These materials are selected primarily for their favourable aesthetic properties and clinical effectiveness. Micro-mechanical adhesion occurs when the adhesive becomes interlocked with the irregularities present on the surface of the substrate. It is believed that higher surface roughness and irregularities improve wettability by increasing the surface area, thus enhancing the bond between the adhered surface and adhesive [5].

Tooth preparation traditionally involves diamond abrasive points and tungsten carbide burs. Recently, ultrasonic tips, coated with fine diamond fragments that conservatively remove tooth surfaces, have been introduced for tooth preparation. Because mastication is primarily a process of cutting or tearing, shear bond strength measures the adhesive strength of the restorative material at the interface between the tooth and the restoration. Consequently, it is necessary to evaluate the strength of bonds using shear mode in order to obtain results that are relevant in a clinical context [6-8]. Although some research has been conducted on different types of tooth preparation, the limited published work primarily concerns the shear bond strength of nanohybrid composites on dentinal walls using ultrasonic tips. The present in-vitro study was aimed to compare the surface roughness of cervical cavity preparations using diamond abrasive points and ultrasonic tips and to measure the shear bond strength after restoring with composite resin. The null hypothesis is that there is no significant difference in surface roughness and shear bond strength of restorative materials between teeth prepared with diamond abrasive points and those prepared with ultrasonic tips.

MATERIALS AND METHODS

The present in-vitro comparative study was performed in the Department of Conservative Dentistry and Endodontics, Guru Nanak Institute of Dental Sciences and Research, Panihati, Kolkata, West Bengal, India, from October 2023 to December 2023. The study was approved by the Institutional Ethics Committee (Reference number: GNIDSR/IEC/21-24/31).

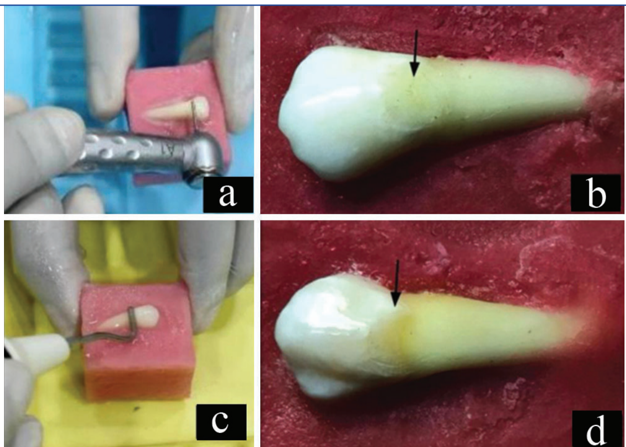
Inclusion criteria: Freshly extracted maxillary 1st premolar teeth extracted for orthodontic reasons were included in the study.

Exclusion criteria: Those teeth with any type of carious lesion, preexisting restoration, decalcification, hypoplasia, severe anatomic variations, cracks, pre-existing cervical lesions, or resorptive defects were excluded from the study.

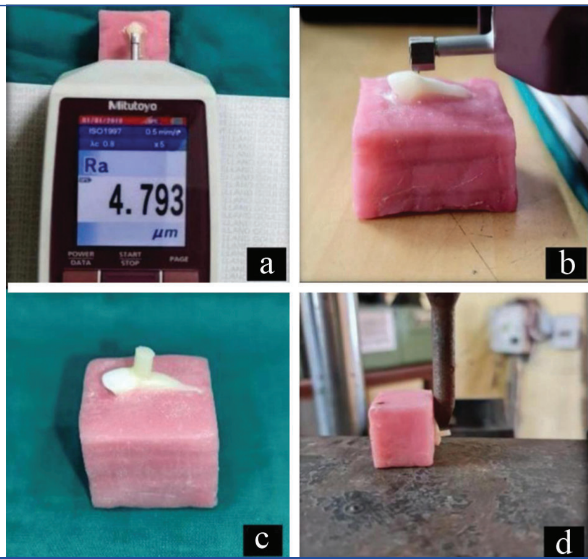
Sample size calculation: Sample size estimation was performed using G*Power software (version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) with a t-test for comparing means between two independent groups. The analysis, set with an alpha level of 0.05 and a power of 80%, yielded a non centrality parameter of 2.8844, a critical t-value of 2.0086, and degree of freedom of 50. The total sample size was 52. (26 per group). This sample size was deemed sufficient for detecting meaningful differences in surface roughness and for evaluating and comparing both surface roughness and shear bond strength of restorative materials between the two groups.

Study Procedure

Teeth (N=52) were cleaned with ultrasonic scalers, disinfected with 2.5% sodium hypochlorite, and stored in 0.1% thymol solution. Using rubber base moulds and cold cure acrylic resin blocks, specimens were prepared for surface evaluation. Group-I (n=26) received surface preparation with a diamond abrasive point (No.835-012, Piranha, SSWhite), while Group-II (n=26) underwent preparation with an ultrasonic tip (Woodpecker G 20) [Table/Fig-1a-d]. Surface roughness (Ra, Rq, Rz) was measured using a digital profilometer (Mitutoya, Japan) [Table/Fig-2a-d]. The Ra coefficient is the average of the absolute profile heights over a specific length of evaluation. Rz is the sum of the highest profile elevation and lowest profile depression within a specific segment of evaluation. Rq is the root mean square of the average profile heights over the same length of evaluation [9]. After conducting a surface evaluation, the specimens were repaired using nanohybrid composite material (Solare X, GC Corporation, Japan). The shear bond strength of the repaired specimens was then measured using a Universal Testing Machine (Model KUT 40, Ratnakar Enterprises, India). A statistical analysis was conducted to compare the results between different groups.



[Table/Fig-1]: A flat surface of 4 mm in width, 4 mm in length, and 1.5 mm in depth was prepared at the cervical region of the buccal surface of the tooth: a) Preparation with a diamond abrasive point; b) Magnified view of (a) with the artificial lesion (marked by arrow); c) Preparation with an ultrasonic tip; and d) Magnified view of (c) with the artificial lesion (marked by arrow).



[Table/Fig-2]: a) Surface roughness measured by a digital surface profilometer; b) Magnified view of (a); c) Specimen ready for shear bond strength measurement; d) Shear bond strength of the specimen measured by Universal Testing Machine.

STATISTICAL ANALYSIS

This has been performed by utilising GraphPad Prism for Windows, Version 10.1.2 (California, USA). Independent samples t-tests were used to analyse differences between groups for outcome variables assessing normality with the Shapiro-Wilk's test, which indicated that the data were normally distributed. The significance level has been set at five percentage.

RESULTS

Significant differences have been found in surface roughness parameters between the two study groups: Group-I exhibited a statistically higher mean for Ra (6.33±2.18 μm) compared to Group-II (4.91±1.57 μm) (p-value=0.0095), for Rq (7.82±2.52 μm) compared to Group-II (5.89±2.01 μm) (p-value=0.0037), and for Rz (30.8±7.96 μm) compared to Group-II (24.8±6.23 μm) (p-value=0.0039) [Table/Fig-3]. However, when considering shear bond strength, no statistically significant difference was observed, indicating weak evidence that Group-I (62±13 MPa) had a higher mean than Group-II (59.3±19.9 MPa) (p-value=0.56) [Table/Fig-4].

Surface roughness parameters	Group-I (n=26)	Group-II (n=26)	p-value[a]
Ra	6.33±2.18	4.91±1.57	0.0095*
Rq	7.82±2.52	5.89±2.01	0.0037*
Rz	30.8±7.96	24.8±6.23	0.0039*

[Table/Fig-3]: Mean surface roughness parameters (μm) of the study groups.
[a]analysed by Independent samples t-test; *The p-value <0.05 was considered statistically significant

Group-I (n=26)	Group-II (n=26)	p-value[a]
62±13	59.3±19.9	0.56

[Table/Fig-4]: Mean shear bond strength (MPa) of the study groups.
[a]analysed by Independent samples t-test

DISCUSSION

The present in-vitro study evaluated the impact of various tooth preparation approaches, using conventional rotary instruments (diamond abrasive points) and ultrasonic tips, on human maxillary first premolars' surface roughness, and on shear bond strength of nanohybrid composite resin (SOLARE X, GC) restorations on prepared tooth surfaces, employing a self-etching adhesive system (G-Premio Bond) with a Universal Testing Machine. Maxillary premolars were selected because NCCLs are more prevalent in maxillary premolars (32.3%) [7].

In the present study, Group-I, where surfaces were prepared using coarse diamond abrasives, exhibited significantly greater roughness compared to surfaces prepared using ultrasonic tips (Group-II). Surface roughness was measured in µm by Ra, Rz and Rq parameters. Youssef M et al., concluded that surface abrasion with an ultrasonic tip produced a more regular sample surface, while conventional diamond abrasives produced an irregular surface depending on the number and size of particles, consistent with the findings of the current study [10]. According to Okda RA et al., mean surface roughness values (Ra) of specimens prepared by utilising diamond abrasives and sono-abrasion were significantly higher than those prepared by utilising carbide burs, which is consistent with the present study [11].

In contrast to the present study, Rapani A et al., demonstrated no significant variations in parameters of (Ra) between enamel and dentin when using a high-speed contra-angle, air turbine handpiece, or ultrasonic device [12]. Similarly, a study by Jelínková H showed no significant difference in surface roughness values between ultrasonic and Erbium: Yttrium Argon Garnet (Er: YAG) laser methods, which differs from the present study [13].

In the present study, an eighth-generation dentin bonding agent (G-Premio Bond, GC Corporation, Japan) was used, as it leaves residual smear plugs that reduce dentinal fluid flow compared to etch and rinse adhesives. It also contains nanosized fillers that enhance resin monomer penetration and increase hybrid layer thickness, improving adhesive mechanical properties [14].

Nanohybrid composite Solare X (GC, Japan) was chosen for its low polymerisation shrinkage and low modulus of elasticity, providing a more flexible and less brittle composite. Low shrinkage is achieved through optimised resin formulation and the use of new-generation prepolymerised fillers.

According to Alzraikat H et al., and Pashley DH and Tay FR the macro-shear test is commonly used to assess bond strength and has gained popularity due to its simplicity and quick results, also useful for screening new adhesive formulations on bonding effectiveness [15,16].

In the present study, Group-I (diamond abrasive points) exhibited higher shear bond strength (62±13 MPa) compared to Group-II (ultrasonic tips) (59.3±19.9 MPa) (p-value=0.56). However, no statistically significant variations have been observed found among the two groups. The reduced bond strength observed with the ultrasonic tip vs conventional diamond abrasive points is attributed to lower surface roughness and microcracks observed on the dentin surface [17]. Borges AB et al., (2011) found no significant differences in shear bond strengths between specimens prepared with ultrasonic diamond-coated tips and those prepared with conventional diamond abrasives, which is consistent with the current study [18]. Additionally, Conde A et al., compared surface treatments with CVDentus ultrasound tips and KG Sorensen diamond burs on etched and non etched dentin, showing that the ultrasonic group exhibited greater bond strength than coarse diamond abrasives, contrasting with the present study [19].

Souza GS et al., (2011) assessed the impact of ultrasonic Chemical Vapour Deposition (CVD) compared to conventional rotary diamond tips on the adhesive strength of composite resin to dentin [20]. The results showed that the average bond strength value of CVD tips was significantly greater than that of rotary diamond tips [20]. However, the use of ultrasonic tips also has disadvantages. Reports indicate that these tips require four times longer for tooth preparation completion [21]. Moreover, their lower cutting efficiency and higher cost compared to conventional diamond abrasives limit their use.

Overall, the null hypothesis regarding surface roughness is rejected, as significant differences were observed between the two preparation methods. Conversely, the null hypothesis concerning shear bond strength is not rejected, as no significant difference was found between the two groups.

Strengths of the present study include providing valuable insights into the surface roughness and shear bond strength of different tooth preparation techniques using comprehensive measurements and statistical analysis. The use of a standardised methodology, encompassing tooth selection, preparation techniques and testing procedures, enhances the study's reliability.

Limitation(s)

The present study has few potential limitations. Firstly, the in-vitro setting may not fully replicate the complex oral environment, which could limit the generalisability of the findings to clinical practice. Secondly, the absence of thermocycling in the experimental set-up may have affected the shear bond strength results, potentially reducing their clinical relevance. Lastly, the use of a digital surface profilometer, as opposed to an optical profilometer, may have impacted the precision of surface roughness measurements.

CONCLUSION(S)

Diamond abrasive points significantly increased surface roughness compared to ultrasonic tips. However, no statistically significant variations have been observed in shear bond strength among the two methods. This suggests that ultrasonic tips may be considered an alternative to diamond abrasive points in clinical settings, avoiding their drawbacks while achieving adequate restoration retention.

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