Effect of two different cavity disinfectants on shear bond strength of composite resin to dentin - an in-vitro study.

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Abstract:

Objective: Using a disinfectant before applying dentin bonding agents can pose a risk of negatively affecting the bond strength of composite resins. This study was carried out to examine the effects of Chlorhexidine (CHX) and Munident on the shear bond strength of composite resins to dentin.

Materials and Methods: A total of 36 permanent teeth were randomly divided into three groups according to the disinfectant used: Group I: control (no disinfectant); Group II: CHX; and Group III: Munident. Dentine bonding agent was applied, and resin composite build-ups were done for shear bond strength (SBS) testing. The SBS was tested using the Instron Universal Testing Machine and the results were statistically analysed.

Results: The results showed that Chlorhexidine and Munident demonstrated effectiveness in enhancing shear bond strength when compared with the control group. Munident showed better results of all the three groups.

Conclusion: Munident can be used as a substitute to chlorhexidine for cavity disinfection as the findings suggested potential of both disinfectants in improving the integrity of dental restorations.

Keywords: Bond strength, Cavity disinfectants, Chlorhexidine, Composite resin, Munident, Restorative dentistry.

Introduction:

Successful dental restoration depends on precise cavity preparation to remove diseased dentin and establish an ideal surface for applying restorative materials. However, even with meticulous preparation, residual microorganisms may remain, potentially causing complications such as secondary caries and pulp inflammation.[1,2] Consequently, the use of disinfectant solutions for post-cavity preparation is essential to eradicate residual bacteria and improve treatment outcomes.[3,4]

Extracellular matrix contains proteolytic enzymes that can degrade proteins called Matrix metalloproteinases (MMPs). Incomplete penetration of adhesive resin into activated MMPs leads to the gradual breakdown of collagen fibers at the resin-dentin adhesive interface, compromising the longevity of the bond.[5–7] Consequently, employing cavity disinfectants that act as MMP inhibitors becomes a viable approach to impede the deterioration of dentinal bonds and enhance the durability of adhesive restorations.

Chlorhexidine digluconate (CHX) is commonly used as an oral antibacterial agent since the 1970s due to its ability to prevent plaque formation and the spread of microorganisms.[8] It is now one of the most widely utilized antibacterial medicines in oral health.[9] Chlorhexidine (CHX) available in various formulations, including mouthrinses with concentrations ranging from 0.12% to 0.2%, cavity-disinfecting solutions with concentrations between 1% and 2%, and gels with concentrations from 0.5% to 1%. These products feature different concentrations and types of CHX, with the 2% solution being the most commonly utilized in clinical dentistry and dental research.[10,11]

The growing availability of synthetic antimicrobial agents has contributed to a worrisome increase in pathogen resistance, posing a significant challenge to effective disease management. Consequently, there is heightened interest in alternative approaches like Ayurveda and Homeopathy, which employ plant-based extracts as medicinal agents. Conventional synthetic cavity disinfectants, such as sodium hypochlorite, iodine-based products and chlorhexidine are associated with adverse effects including pulp irritation, staining, and cytotoxicity. Additionally, prolonged use of these agents can result in bacterial resistance, reduced bond strength, and increased microleakage. Herbal extracts, including Neem leaf, Propolis, Noni fruit, Miswak, and Licorice, present a promising alternative. These natural agents possess antimicrobial properties, are cost-effective, and exhibit minimal cytotoxicity, making them a viable solution to address the limitations of synthetic antimicrobials.[12]

In recent years, there has been a noticeable decline in the effectiveness of synthetic antimicrobial drugs due to the rise in pathogen resistance, posing a significant threat to disease treatment.[12,13] As a result, there has been a surge in interest towards Ayurveda and homeopathy, which utilize plant extracts as medicinal alternatives. Munident crushable tablets, composed of natural ingredients containing Cinnamomum zeylanicum, Santalum album, Berberis aristata, Cyperus rotundus, Symplocos racemose and Curcuma longa have

demonstrated antimicrobial efficacy.[14] Ayurveda claims that they have minimal to no adverse effects as they do not contain any chemicals.[15]

The current study aims to investigate the impact of disinfectant application on shear bond strength, comparing the effectiveness of Munident powder and chlorhexidine, and examining the variation in shear bond strength across different disinfectant and bonding systems. This study seeks to provide valuable insights into the optimal selection and application of cavity disinfection protocols in restorative dentistry. There is no significant difference in shear bond strength (SBS), according to the null hypothesis values when chlorhexidine and Munident tablets are used as disinfectants.

Materials and Methods

The study received approval from the Institutional Ethical Committee (CDCRI/DEAN/EC/CONS/PG-01/2024). A total of 36 intact permanent maxillary and mandibular teeth, extracted due to pericoronitis, impaction, or orthodontic requirements, were included. After eliminating calculus and soft tissue debris, to expose the mid-coronal dentin, specimens were sectioned with a low-speed diamond disk while cooling in water. The sectioned halves, along with their roots, autopolymerizing acrylic resin was used to manufacture blocks with internal measurements of 1.5 cm by 1.5 cm by 1.5 cm. The dentin surfaces were then flattened using polishing paper.

The specimens were further randomly assigned into 3 groups, each comprising 12 teeth:

Group 1 (Control): Samples that were not subjected to any cavity disinfectant treatment and functioned as the control group. (n=12)

Group 2: Teeth treated with Chlorhexidine digluconate 2% solution, (n=12) actively applied with an applicator tip for 30 seconds, and rinsed for 30 seconds.

Group 3: Munident Tablets (500 mg), (n=12) were crushed into powder form and 100 mg of this powder was mixed with 1 milliliters of water.[14] This solution was actively applied with an applicator tip for 30 seconds and rinsed for 30 seconds.

37% phosphoric acid was used to etch the exposed dentinal surfaces for 15 seconds, followed by rinse with water. Afterward, the dentinal surfaces were air-dried for 15 sec. A bonding agent, BeautiBond by Shofu (Japan), was applied with an applicator tip for 20 seconds and subsequently light-cured for 40 seconds. Composite resin (Beautifil by Shofu, Shade A2) was incrementally placed in 2–3 layers within a polyethylene tube (diameter: 3 mm, height: 2 mm). The extra composite material was carefully removed off the edges using an explorer, and an LED curing light was utilized to cure the material for 20 seconds (Figure 1). The polyethylene tubes were then removed.

For 24 hours, all samples were stored in distilled water at 37°C, to simulate oral environment. A universal testing (Tinius Olsen, Model No. 25ST) equipment was then utilized to test the

samples for shear bond strength (SBS). The blade of the apparatus was positioned perpendicular to the composite cylinders and in line with the teeth's long axis because of the configuration (Figure 2). Until the composite cylinders separated from the dentinal surface, a crosshead speed of 1 mm/min was employed.

Descriptive statistics were evaluated and tabulated in terms of mean and standard deviation, utilizing SPSS version 25 for Windows (Statistical Package for Social Sciences, SPSSInc, Chicago, IL). The SBS values were statistically analysed utilizing One Way ANOVA and post hoc tukey test with p value < 0.05 as statistical significance.

Outcome assessment –

The weight required to separate the composite cylinders was recorded, and shear bond strength value was calculated using the following formula:

Bond strength = Force (in kg) required to detach the composite cylinder × 9.8/total surface area.

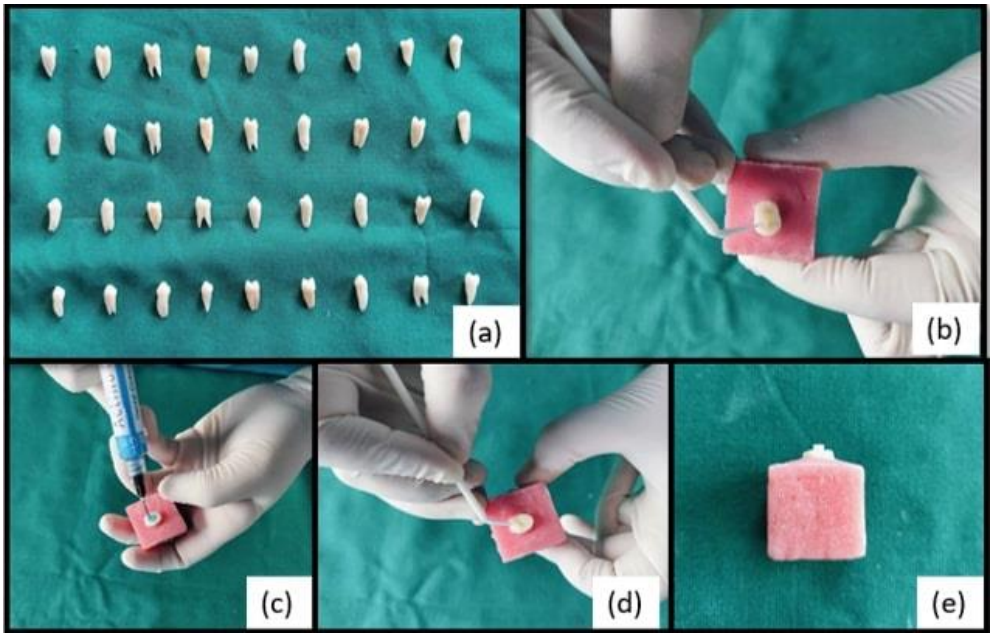

Figure 1: Evaluation of shear bond strength: (a) Extracted premolars, (b) Application of cavity disinfectant solution, (c - e) Etching, application of bonding agent followed by composite buildup

Figure 2: Testing of shear bond strength using universal testing machine

Results

For each group, the mean SBS and standard deviation values were acquired. The mean values and associated standard deviations (SD) are used to report the results. Group comparisons were conducted using post hoc testing and one-way ANOVA for statistical comparisons.

Shear bond strength data, including mean and standard deviation values, are provided for each group in Table 1. The mean ± SD of group I is 7.46 ± 0.89, of group II is 12.51 ± 1.03, and of group III is 13.47 ± 1.13. The table 1 shows that Munident had the best shear bond strength closely accompanied by chlorhexidine, while the control group exhibited the least values of bond strength. Table 2 display the mean SBS values along with their standard deviations for the test groups.

Intergroup comparison –

When groups I and II were compared, the mean difference between them was 5.05 MPa, indicating a highly significant difference. There was a highly significant difference between groups I and III, as indicated by the mean difference between them of 6.01 MPa. Groups II and III did not differ significantly from one another, as seen by their mean difference of 0.96 MPa when compared.

The results interpreted that Munident was the best, followed by chlorhexidine, but the difference was non-significant. The control was not as effective as the other two groups (Table 2).

Table 1: Table showing mean and standard deviation obtained of various groups using One way Descriptive statistics

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	12	7.46	.89	.258	6.8919	8.0314
CHX	12	12.51	1.03	.299	11.8529	13.1705
Munident	12	13.47	1.13	.328	12.7501	14.1983

Table 2: Table showing Post Hoc Tukey for multiple comparison between the groups

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	CHX	-5.05*	.420	**.000**	-6.0810	-4.0190
	Munident	-6.01*	.420	**.000**	-7.0435	-4.9815
CHX	Control	5.05*	.420	**.000**	4.0190	6.0810
	Munident	-.96	.420	.071	-1.9935	.0685
Munident	Control	6.01*	.420	**.000**	4.9815	7.0435
	CHX	.96	.420	.071	-.0685	1.9935

Discussion

The effectiveness of a cavity disinfectant depends on its intrinsic properties, the substrate type, and the materials used in the restorative process. An ideal disinfectant should exhibit biocompatibility, possess antibacterial activity, and thoroughly clean the cavity without compromising the bond strength or the dentin-resin interaction.[15]

Dentin and enamel exhibit distinct structural and compositional differences. Dentin, a moist substrate with high organic content, poses challenges for adhesive procedures. Bond strength levels vary according to the nature of dentin, which includes healthy versus caries-affected and superficial versus deep dentin.[14,15]

Superficial dentin is characterized by a higher proportion of intertubular dentin, greater organic content, and fewer dentinal tubules compared to deep dentin, making it more hydrophobic and enhancing the efficacy of cavity disinfectants. In contrast, caries-affected dentin is partially demineralized, which increases its porosity and impairs adhesive penetration, resulting in a weaker adhesive interface. To optimize the experimental protocol and reduce variability, superficial healthy dentin was chosen as the standardized substrate for all procedures in this study.[14]

The clinical success of a restoration largely depends on the bonding strength between dental tissues and the restorative material. This bond is facilitated by the hybrid layer, a structural entity formed by the integration of dental hard tissues and resin. The performance and durability of this hybrid structure are significantly influenced by factors such as: Dentin structural properties, Surface preparation and Variations in adhesive system application methods.[16]

The primary component accountable for the degradation of the bond between adhesive and dentin is the breakdown of exposed collagen fibrils inside the hybrid layer. This is mostly caused because of the activity of the MMP enzymes found in dentin, which are initiated when low pH is produced during the acid etching process when zinc and calcium ions are present.[16,17]

Chlorhexidine (CHX) being a versatile agent in dentistry, commonly used as a root canal irrigant, disinfectant, and mouthwash. Its ability to rewet and bind to tooth structures makes it an attractive adjunct in restorative procedures. While CHX's antibacterial properties have led some authors to suggest that it may enhance dentin bond strength, the evidence is inconsistent. Some studies have concluded, CHX has negligible adverse effects on shear bond strength, whereas others have reported a positive impact on bond strength.[8,9]

Munident tablets have demonstrated superior clinical results due to their unique blend of multiple ingredients, which collectively exhibit analgesic, antifungal, antiviral, antioxidant, antimicrobial, anti-inflammatory and wound-cleansing properties. The tablets' efficacy can be attributed to the synergistic effects of their constituent herbs, including: Santalum album (30 mg), Berberis aristata (20 mg), Cyperus rotundus (20 mg), Symplocos racemosa (20 mg), Cinnamomum zeylanicum (20 mg) and Curcuma longa (20 mg). These herbs have been found to possess beneficial antibacterial properties, contributing to the tablets' overall therapeutic effectiveness.[14]

Various strategies have been proposed to enhance the resin-dentin bond strength and longevity.[18] MMP inhibition is one of them. Both Munident (Glycyrrhiza glabra L.) and Chlorhexidine have strong antibacterial properties. Chlorhexidine can effectively inhibit MMPs, specifically MMPs 2, 8, and 9.[19,20] The chelating effect of chlorhexidine which scavenges calcium and zinc ions is thought to be responsible for its MMP inhibitory action.[21] The ingredients found in Munident may be responsible for its MMP inhibiting properties.

Studies on the use of chlorhexidine as a cavity disinfectant has demonstrated its effectiveness in reducing Streptococcus mutans concentrations on exposed carious root surfaces and within occlusal fissures. Using chlorhexidine as a disinfectant after tooth preparation and before bonding agent application has been suggested as a method to minimize the risk of postoperative sensitivity and residual caries. However, some studies have indicated that increased microleakage associated with chlorhexidine use may hinder the bonding adhesive's ability to form a strong connection with the dentin.[20,22]

However, an in vitro study demonstrating antibacterial action of Munident also showed that this phytotherapeutic substance suppressed the growth of many oral pathogens, including Streptococcus mutans.[23] Furthermore, it was discovered that Munident extract may stop S. mutans from growing, which makes it very beneficial for preventing secondary caries.[14]

Cavity disinfectants are a significant factor influencing the bonding of adhesive resins. Research has demonstrated that using cavity disinfectants in conjunction with adhesive resins can enhance bonding strength and reduce postoperative sensitivity.[11] This improved bonding performance is largely attributed to the wetting effect of disinfectants, which facilitates a stronger bond between the resin and tooth structure.

In this in vitro study, the impact of several cavity disinfectants on the strength of the bond between permanent dentin and composite resin was investigated. All of the tested disinfectants had no effect on adhesion, according to the results. In reality, all disinfectant groups exhibited stronger shear bonds than the control group; Munident and Chlorhexidine showed statistically significant differences.

The results of this investigation are consistent with those of studies conducted by Sinha et al. and Boiter et al., which demonstrate that CHX has a stronger bond than the control group by preventing the activation of MMPs in the dentin.[9,24]

They also proposed that applying 2% CHX could prevent degradation of hybrid layer, which would have a beneficial effect on maintaining bond strength.[17,25] Additionally, chlorhexidine has a great affinity for tooth structure and an excellent rewetting capability, both of which contribute to stronger bonds.[16]

Munident (Glycyrrhiza glabra L.) contains *Cyperus rotundus, Berberis aristata, Symplocos racemosa, Santalum album, Cinnamomum zeylanicum and Curcuma longa* which are responsible for its bactericidal activity.[14] The findings of the current study disclosed that applying Munident to a prepared dentinal surface enhances the durability of the resin-dentin adhesion. It aligns with the study performed by Kapil et al, though in that research, primary teeth were evaluated.[15] While the SBS values were considerably higher than those of the control group, the shear bond strengths difference of the two test groups was statistically nonsignificant. The outcome of the current study revealed that shear bond strengths of Munident was equally efficacious as chlorhexidine. The findings of the study caused the partial rejection of the null hypothesis due to presence of statistically non-significant difference between both the test groups.

The limitation of study lies in the small sample size, which decreased its statistical power to find a significant difference amongst the two groups, despite both demonstrating efficacy. Given the potential for cavity disinfectants to diffuse through dentin in deep cavities, similar to resin monomers, to examine their biological effects on dental pulp cells in vitro, more research is necessary. Furthermore, research employing bacterial cultures can yield important information on their strain specificity and antimicrobial activity. Although this in vitro study has limitations in replicating the complexities of the intraoral environment, it contributes to the accumulation of scientific evidence and lays the groundwork for future clinical studies, which are currently scarce.

Conclusion

Considering the results of the study, it can be concluded that application of Chlorhexidine and Munident as cavity disinfectants does not negatively impact the SBS values of bonding adhesive to dentin. Considering the limitations of Chlorhexidine, such as causation of increased chances of micro-leakage, bacterial resistance and weak bond strength after long term use, the authors recommend considering Munident as a substitute for disinfection of the cavity. Nevertheless, further long-term clinical trials conducted in vivo are necessary to validate these results.

Conflicts of interest

There are no conflicts of interest.

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