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Effect of 10-MDP-containing versus non-MDP Adhesives on delayed shear bond strength to enamel and dentine

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Abstract

Background: Effective bonding between restorative materials and dental substrates is critical for the longevity of composite restorations. Adhesives containing 10-MDP have demonstrated superior chemical bonding and durability compared to traditional self-etch systems.

Aim: To compare the shear bond strength (SBS) of an MDP-containing adhesive (Renew MDP) with two seventh-generation self-etch adhesives—Prime Restorite Bond 7 and Beauti Bond (Shofu).

Materials and methods: Thirty extracted human molars were sectioned to expose flat enamel and dentin surfaces. Samples were randomly divided into three groups with 10 (n=10) for each adhesive. Composite resin cylinders were bonded to the prepared surfaces following the manufacturer's instructions. Shear Bond Strength was performed after 90 days using a universal testing machine at a crosshead speed of 1 mm/min. Data were analysed using one-way ANOVA and post-hoc Tukey tests ($p < 0.05$).

Results: Renew MDP showed significantly higher shear bond strength values to both enamel and dentin after 90 days compared to Prime Restorite Bond 7 and Beauti Bond ($p < 0.05$). Among the self-etch adhesives, Beauti Bond performed better than Prime Restorite Bond 7 but was still inferior to Renew MDP.

Conclusion: The MDP-containing adhesive (Renew MDP) exhibited superior shear bond strength, suggesting improved clinical performance compared to conventional seventh-generation adhesives.

Keywords: 10-MDP, dental bonding, dentin, enamel, Renew MDP, self-etch adhesive, shear bond strength.

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1. Introduction

Achieving reliable adhesion between restorative materials and dental substrates remains a cornerstone of modern adhesive dentistry. The longevity and success of composite restorations are significantly influenced by the bond strength between the restorative material and the tooth surface, particularly enamel and dentin [1]. Among the various methods to evaluate this adhesion, shear bond strength (SBS) testing is one of the most commonly employed due to its simplicity and reproducibility [2]. Dental bonding agents have evolved through multiple generations, reflecting advances in chemistry, technique sensitivity, and clinical performance. The 7th generation bonding agents, also referred to as "all-in-one" adhesives, combine etchant, primer and adhesive in a single bottle, facilitating ease of use and reducing procedural steps [3,4]. However, these simplified systems may sometimes compromise bond strength due to limited demineralisation and hybrid layer formation [5].

Prime Restorite Bond 7 and Beauti Bond (Shofu), two commercially available 7th-generation self-etch bonding agents, exemplify this category. It offers clinical convenience, but concerns persist regarding its long-term bonding efficiency and water sorption characteristics [6,7]. On the other

hand, modern adhesives containing 10-methacryloyloxydecyl dihydrogen phosphate (MDP) have shown improved chemical bonding to hydroxyapatite and greater durability of the adhesive interface [8]. Renew MDP from Prevest DenPro incorporates this monomer and claims enhanced bond strength and resistance to hydrolytic degradation. The unique functional monomer MDP plays a critical role by forming stable calcium salts and facilitating nano-layering, which contributes to stronger and more stable bonds [9,10].

Numerous studies have highlighted the superior performance of MDP-based adhesives compared to traditional self-etching systems [11,12]. Furthermore, the interaction of MDP with the smear layer and its ability to penetrate dentin tubules has been shown to improve both immediate and aged bond strength [13,14]. Due to the chemical and functional differences between MDP-containing adhesives and 7th-generation self-etch systems, there is a necessity to evaluate their bond strengths comparatively under standardised conditions.

Despite the abundance of literature on individual systems, head-to-head comparisons, especially involving newer market entrants like Renew MDP, remain scarce. This study aims to evaluate and compare the SBS of Renew MDP (Prevest DenPro, Jammu, India), a 10-MDP-containing adhesive, with Restorite Bond 7 (Prime, India) and Beauti Bond (Shofu, Japan), 7th-generation self-etch bonding agents. The results of this study may provide valuable insights into the clinical efficacy of these adhesives, guiding practitioners in selecting materials for enhanced restorative outcomes.

2. Materials and methods

After extraction, a total of thirty healthy and structurally sound permanent mandibular molars, free from any signs of caries, were carefully selected for the study. These teeth were meticulously cleaned to eliminate any traces of blood, calculus buildup, or organic debris adhering to the surface. Once cleaned, the teeth were immersed and maintained in a solution of normal saline to preserve their natural hydration and structural integrity.

To ensure uniformity in the cavity depth across all specimens, the occlusal surface of each molar was drilled precisely at the central fossa. A round-shaped diamond bur (model SF 21, manufactured by Prime and Dental, Mumbai) was employed for this task, producing a depth of exactly 1.5 mm. Subsequently, the teeth underwent trimming using an orthodontic trimmer until the full depth of the drilled region was reached, thereby exposing a flat dentin surface. To form a consistent smear layer across the exposed dentin, the surface was then polished using 600-grit silicon carbide abrasive paper. After this polishing step was completed, the teeth were placed back into a container with normal saline and stored at ambient room temperature conditions. For the next phase, each tooth was oriented so that the prepared bonding surface faced downward inside a cylindrical mold with dimensions of 25 mm in both height and width. A slow-curing, highly viscous resin material was poured into the mold, embedding the tooth securely while it was positioned on a flat working platform. Once the resin had fully polymerised and solidified, the mounted specimen was promptly removed from the mold to proceed with the following procedures.

To prepare for the bonding evaluation, the specimen was submerged in demineralised water for approximately twenty minutes to rehydrate the structure. After the soaking period, the tooth surface designated for bonding was further refined using 120-grit sandpaper to expose a flat area adequate for composite application. This exposed area was adjusted to accommodate a resin composite button with a standardised diameter of 2.38 mm. A final polish was performed using 400-grit sandpaper, ensuring the surface became smooth and uniform, as assessed visually. Lastly, the prepared tooth was carefully rinsed with clean water to remove any remaining debris and dried thoroughly using a piece of tissue paper.

The various adhesives (Figure 1) along with their compositions and application steps are presented in Table 1. In Group 1, Renew MDP (Prevest Denpro, India) was applied as a single coat to the enamel and dentinal surfaces, left undisturbed for 20 seconds, air-dried with a strong blast for 5 seconds, and light-cured for 30 seconds. In Group 2, Prime Restorite Bond 7 was applied following the same protocol. In Group 3, Beauti Bond (Shofu) was also applied using the identical procedure (Table 1). After the adhesive had cured, the tooth specimen was secured in a bonding clamp equipped with a white plastic button mold featuring an aperture with a diameter of 2.38 ± 0.03 mm. The mold opening was carefully aligned with the prepared bonding surface to ensure that only the intended substrate was exposed to the

bonding agent. The clamp screw was tightened until the spring was compressed halfway, taking care to avoid any distortion or arching of the plastic mold. Next, the resin composite material was applied directly onto the bonding area within the mold opening. Once applied, the screw was loosened, and the specimen was gently removed from the mold. The samples were then immersed in demineralised water maintained at 37 ± 1°C for 24 ± 2 hours to simulate oral conditions. Following this conditioning period, the specimens were taken out and blotted dry with tissue paper. Specimens were stored in distilled water in an incubator at 37° C for 90 days.

SBS testing was performed after 90 days, conducted by applying force at a crosshead speed of 1.0 ± 0.25 mm/min until failure occurred. The maximum load at the point of fracture was recorded, along with the corresponding load versus displacement curve.

The mean SBS values were calculated for each group, and the results were statistically evaluated using one-way analysis of variance (ANOVA) for both enamel and dentin separately. Following this, multiple comparisons were performed with Tukey's post hoc test, and the threshold for significance was set at $\alpha = 0.05$.

3. Results

The mean SBS to enamel and dentin were assessed for three experimental groups. Among the tested adhesives, Group 1 (Renew MDP) demonstrated the highest mean SBS, with values of 27 ± 3.6 MPa to enamel and 22 ± 2.3 MPa to dentin, which were significantly superior to the other groups. Group 3 (Beauti Bond) showed intermediate bond strength values, measuring 22.11 ± 3.1 MPa for enamel and 18.01 ± 2.7 MPa for dentin, which were lower than Renew MDP but higher than Restorite Bond 7. The lowest bond strengths were recorded for Group 2 (Restorite Bond 7), with 14.2 ± 5.1 MPa to enamel and 8.13 ± 4.7 MPa to dentin, indicating comparatively weaker adhesion to both substrates (Figure 2).

One-way ANOVA indicated a significant difference in SBS between the adhesives ($P < 0.05$). Post hoc analysis revealed that the differences in mean bond strength between all three groups were statistically significant. The comparison of the two self-etch adhesives with different solvent compositions showed notable variation in mean bond strength values. These findings further confirmed that the differences among the groups were statistically significant ($P < 0.05$), with Group 1 (Renew MDP) demonstrating the highest bond strength to both enamel and dentin.

Figure 1. Materials used in the study

Table 1. The composition and application steps of various adhesives used in the study.

Group	Bonding Agent	Manufacturer	Key Components	Application Steps
1	Renew MDP	Prevest Denpro, India	• 10-MDP • Urethane Dimethacrylate • Bis-GMA • Ethanol • Triethylene Glycol Dimethacrylate	One coat applied → 20 sec undisturbed → Air dried 5 sec (gentle blast) → Light cured 30 sec
2	Restorite Bond 7	Prime, India	• HEMA • Bis-GMA • Ethanol • TEGDMA	One coat applied → 20 sec undisturbed → Air dried 5 sec (gentle blast) → Light cured 30 sec
3	Beauti Bond	Shofu, Japan	• Phosphonic Acid Monomers • Bis-GMA • TEGDMA • Acetone • Water	One coat applied → 20 sec undisturbed → Air dried 5 sec (gentle blast) → Light cured 30 sec

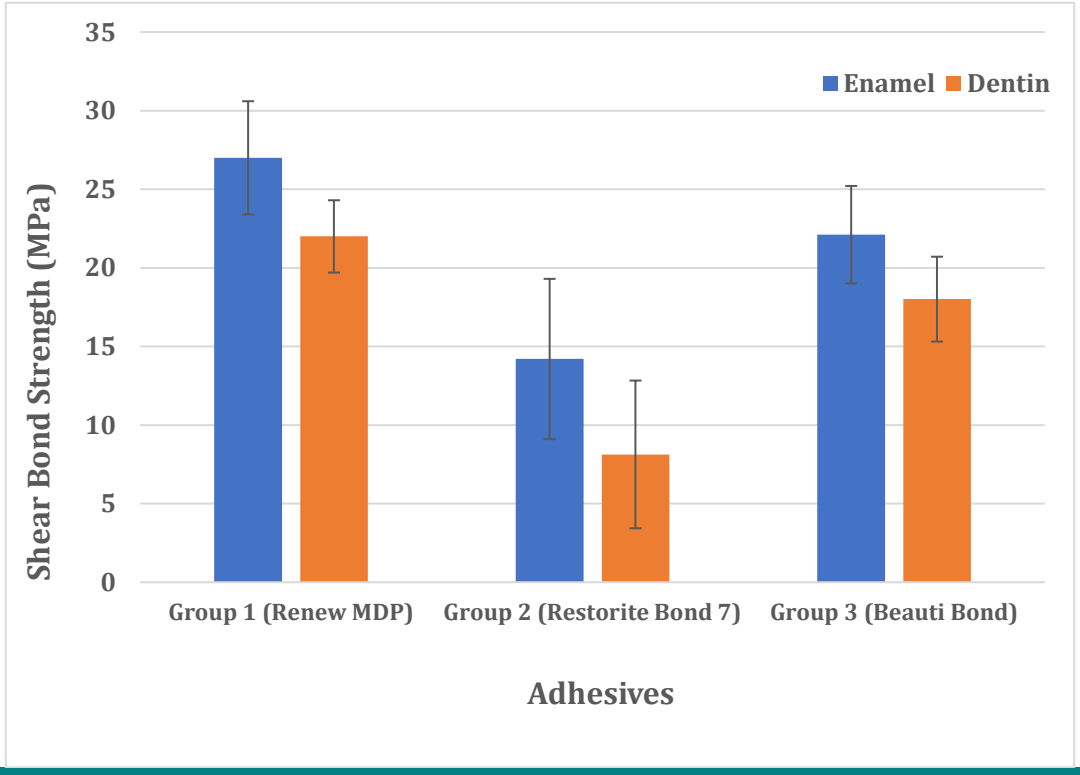

Figure 2. Comparison of shear bond strength (MPa) of different adhesives with enamel and dentin substrates.

4. Discussion

The findings of this in-vitro study highlight that the 10-MDP-containing adhesive (Renew MDP) exhibited significantly higher SBS to both enamel and dentin compared to seventh-generation self-etch adhesives (Beauti Bond and Prime Restorite Bond 7) after 90 days of storage. This aligns with emerging literature emphasising the durability and chemical bonding ability of MDP-based adhesives. The superior performance of Renew MDP can be attributed to the formation of stable MDP-calcium salts at the adhesive interface and its ability to resist hydrolytic degradation through nano-layering and chemical stability [15]. A 90-day storage period was selected to simulate the ageing of the adhesive interface and assess the durability of the bond over time, as prolonged water storage has been shown to challenge the hydrolytic stability of adhesives [16].

Recent studies have demonstrated that MDP-containing adhesives maintain their bonding performance over time, especially in aged conditions, owing to their relatively hydrophobic structure and reduced water sorption compared to

traditional HEMA-based self-etch adhesives [16]. Moreover, MDP's capacity to chemically interact with hydroxyapatite enhances interfacial stability, which becomes particularly relevant in long-term clinical scenarios. Renew MDP's higher SBS values after ageing suggest it is more resistant to hydrolytic and enzymatic degradation—critical for restoration longevity.

The moderate performance of Beauti Bond may stem from its inclusion of phosphonic acid-based monomers, which offer limited chemical interaction with hydroxyapatite compared to MDP. Furthermore, the use of acetone as a solvent increases technique sensitivity, potentially affecting monomer infiltration and polymerisation efficiency if evaporation is not well-controlled [17,18].

In contrast, the significantly lower SBS of Prime Restorite Bond 7 may be due to its HEMA-rich formulation, which, while improving wetting, introduces increased water sorption and long-term degradation risks [19]. These limitations are consistent with earlier findings indicating that hydrophilic components may compromise the mechanical stability of the adhesive interface over time [20].

Another factor to consider is the inherent limitation of self-etch adhesives when bonding to enamel. Due to their mild acidity, these systems do not demineralise enamel deeply enough to form robust resin tags, resulting in inferior micromechanical retention compared to etch-and-rinse or MDP-based systems [21,22]. Renew MDP, although a self-etch adhesive, likely compensates for this through its chemical bonding properties and deeper infiltration facilitated by its optimised monomer composition.

However, the limitation of the present study is the absence of thermocycling, a standard artificial ageing method that better simulates intraoral temperature variations and their impact on the resin–dentin interface. The use of thermocycling may influence bond degradation patterns, and future studies incorporating this variable would provide more clinically relevant data.

From a clinical standpoint, the significantly higher bond strengths achieved by Renew MDP underscore its potential advantage in high stress-bearing areas, such as posterior occlusal restorations or Class II composite restorations, where adhesive durability is paramount. Practitioners may consider Renew MDP as a preferable option when restoration longevity and reduced failure risk are critical, especially under occlusal load or moisture-rich environments.

Further studies involving thermocycling, SEM, cyclic fatigue loading, and in vivo evaluation are recommended to validate the long-term clinical implications of these findings and to assess marginal integrity and failure rates over time.

5. Conclusion

Within the limitations of this in-vitro study, it can be concluded that adhesives containing 10-MDP demonstrated superior bond strength to both enamel and dentin after 90 days of storage, compared to non-MDP-based seventh-generation self-etch adhesives. The chemical interaction of 10-MDP with hydroxyapatite likely contributed to enhanced adhesive stability and durability. These findings highlight the importance of functional monomers like 10-MDP in improving long-term bonding performance. Further long-term in vivo studies are recommended to validate these results and assess the clinical implications in terms of restoration longevity and failure rates.

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