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In Vitro Comparative Evaluation of Shear Bond Strength in 10-MDP Dental Adhesive Systems: Assessing Performance and Clinical Relevance

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Abstract

Background: The longevity and success of adhesive dental restorations depend heavily on the bond strength between the tooth substrate and restorative materials. 10-Methacryloyloxydecyl dihydrogen phosphate (10-MDP) is a functional monomer known to form durable chemical bonds with hydroxyapatite. This study aimed to compare the tensile bond strength of two MDP-based bonding agents: Renew MDP (Prevest DenPro) and Clearfil SE Bond (Kuraray Noritake Dental Inc.).

Methodology: Forty extracted, caries-free mandibular molars were prepared to expose flat dentin surfaces and embedded in acrylic resin. Specimens were divided into two groups (n=20 each) based on the adhesive used. Bonding protocols followed manufacturers' instructions, and composite resin was applied in increments using a cylindrical mold. After 24-hour storage in saline at 37°C, shear bond strength was measured using a Universal Testing Machine at a crosshead speed of 1 mm/min. Data were analyzed using one-way ANOVA and Tukey's post hoc test (α=0.05).

Results: The mean shear bond strength was 18.41 MPa for Renew MDP and 18.98 MPa for Clearfil SE Bond. Although Clearfil SE Bond showed slightly higher bond strength, the difference was not clinically significant.

Conclusion: There was no substantial difference in the shear bond strength between Renew MDP and Clearfil SE Bond, suggesting that both adhesives perform comparably in vitro.

Keywords: Calculus Hydroxyapatite, MDP, Materials

Introduction

The success of adhesive dentistry largely depends on the ability of bonding agents to provide durable and stable adhesion between the tooth substrate and restorative materials. Bonding agents serve as critical intermediaries, creating a micromechanical and chemical bond that ensures the longevity of restorations, reduces microleakage, and preserves tooth structure.[1] The evolution of dental adhesives from multi-step systems to simplified versions has been driven by the desire to enhance clinical efficiency without compromising bond strength or durability.[2] A significant advancement in adhesive technology has been the incorporation of functional monomers, particularly 10-Methacryloyloxydecyl dihydrogen phosphate (10-MDP). MDP is a hydrophilic monomer with a phosphate group capable of chemically bonding to calcium ions in hydroxyapatite, forming a stable and hydrolytically resistant bond.[3] This chemical interaction provides a dual bonding mechanism—both micromechanical interlocking and chemical adhesion—resulting in enhanced bond durability and improved clinical performance.[4] The long-term bond stability of MDP-containing adhesives is attributed to the formation of a nano-layered structure at the adhesive interface, which is highly resistant to degradation over time.[5] In fact, it has been emphasized that “the durability of adhesive interfaces largely depends on their chemical stability at the molecular level”.[6] Consequently, adhesives containing MDP, such as Clearfil SE Bond (Kuraray Noritake Dental Inc.), have been widely regarded as the gold standard against which newer materials are compared.[7] Renew MDP (Prevest DenPro), a newer entrant in the market, also claims to utilize MDP technology to enhance bonding efficacy, but there is limited independent research comparing its performance to well-established systems like Clearfil SE Bond. A wide variety of factors, including the type of adhesive monomer and application protocol, significantly influence the quality of the adhesive interface.[8]Therefore, despite the theoretical benefits of MDP incorporation, variations in resin formulation, filler content, solvent systems, and curing protocols can impact clinical outcomes.[9] Although contemporary adhesives share similar core components, subtle differences in their chemical compositions can dramatically affect their clinical behavior.[10] Given these considerations, empirical evaluation through comparative studies is necessary to verify manufacturers' claims and guide evidence-based clinical decision-making. The present study aims to compare the shear bond strength of two MDP-containing bonding agents—Renew MDP from Prevest DenPro and Clearfil SE Bond from Kuraray Noritake Dental Inc. This comparison will help ascertain whether the newer bonding agent matches or surpasses the performance of the established product, providing valuable insights for clinicians seeking reliable adhesive systems for restorative procedures.

Material and Methodology

Table 1 contains a list of the self-etch adhesives utilized in the investigation. Following their recent extraction, forty undamaged, caries-free permanent mandibular molars were gathered, cleared of calculus, blood, and debris, and then preserved in regular saline. To standardize the depth of cavitation, the teeth were drilled to a depth of 1.5 mm in the deepest portion of the central fossa of each tooth's occlusal surface using a round diamond bur (SF 21, Prime and Dental, Mumbai). To reveal the flat dentinal surface, all of the teeth were ground using an orthodontic trimmer until the drilled hole depth was reached. To create a consistent smear layer, the flat dentinal surfaces were then polished using 600 grit silicon carbide paper (3M Products). After finishing, the teeth were then stored in the normal saline at room temperature. The tooth was placed with the bonding side facing downward in a cylindrical mold measuring 25 mm × 25 mm on a level working surface. A slow-setting, viscous curing resin was poured into the mold to embed the tooth. Once the potting medium had set, the mounted tooth was removed from the mold as soon as possible and stored in demineralized water for 20 minutes. After storage, the mounted tooth was removed and the bonding area was ground using 120 grit sandpaper until an area sufficient to accommodate a resin composite button with a diameter of 2.38 mm was exposed. This was followed by polishing with 400 grit sandpaper until the surface appeared smooth and even upon visual inspection. The mounted tooth was then cleaned with water and dried using tissue paper.

Group 1: Renew MDP (Prevest Denpro, India) was applied as one coat on the dentinal surface, left undisturbed for 20 seconds, dried with a strong blast of air for 5 seconds, and was light cured for 30 seconds.

Group 2: Clearfill SE Bond (Kuraray) Clearfill SE primer was applied first and left for 20 seconds, air dried. After that Clearfill SE Bond was applied as one coat on the dentinal surface, left undisturbed for 5 seconds, dried with a strong blast of air for 5 seconds, and was further light cured for another 10 seconds.

Following adhesive curing, the mounted tooth was inserted into a bonding clamp fitted with a white plastic button mold containing a hole with a diameter of 2.38 ± 0.03 mm. The mold opening was centered over the prepared bonding area, ensuring that the bonding surface consisted solely of the specified substrate. The clamp screw was tightened until half of the spring was compressed and no arching of the plastic mold occurred. Resin composite was then applied to the bonding surface within the mold. After application, the screw was loosened and the specimen was carefully removed from the mold. The specimen was then stored in demineralized water at 37 ± 0°C for 24 ± 2 hours. After conditioning, it was removed from the water, dried with tissue paper, and placed in a universal testing machine. The sample was subjected to a shear bond strength test at a crosshead speed of 1.0 ± 0.25 mm/min until fracture occurred. The peak load at failure was recorded, and the corresponding load-displacement graph was documented. The mean values of shear bond strength were calculated for each experimental group and the data were analyzed by one way analysis of variance (ANOVA). Post hoc comparisons were carried using Tukey's test with the statistical significance set at α = 0.05.

Figure 1: Renew MDP

Figure 2: Clearfill SE Primer and Bond

Table 1: Materials used in study

Self-etch Adhesive	Manufacturer	Composition
Renew MDP	Prevest DenPro	BisGMA, Urethane Dimethacrylate, Triethylene Glycol Dimethacrylate, 2-Hydroxyethyl Methacrylate, Camphorquinone, Dimethyl Amino Ethyl Methacrylate, Ethyl 4-dimethyl Amino Benzoate, Ethanol, Water, 10-MDP, Butylated Hydroxy Toluene
Clearfil SE Bond	Kuraray Noritake Dental Inc.	10-MDP, 2-Hydroxyethyl Methacrylate (HEMA), BISGMA, Hydrophilic dimethacrylate, dl-Camphorquinone, Silanated colloidal silica, N-Diethanol-p-toluidine
Clearfil SE Primer	Kuraray Noritake Dental Inc.	10-MDP, 2-Hydroxyethyl Methacrylate (HEMA), Hydrophilic dimethacrylate, dl-Camphorquinone, N-Diethanol-p-toluidine, Water

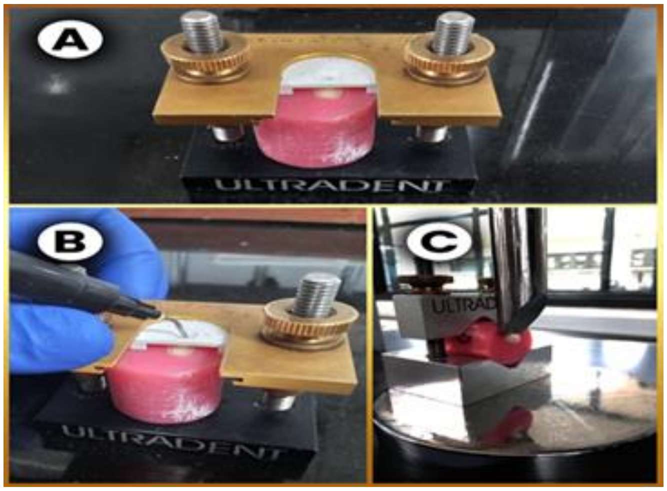

Figure 3: Specimen preparation. (A) An acrylic-resin embedded tooth was mounted onto the bonding clamp and bonding mold. (B) Composite was bonded onto either dentin or enamel surface. (C) Shear bonding test was then performed

Results

Table 2 displays the standard deviations and mean tensile bond strength data. The mean tensile bond strength for GROUP II Clearfill SE Bond was 18.98 MPa, while the bond strength for GROUP I Renew MDP was 18.41 MPa. Since debonding force is a continuous variable, the means and standard deviations of the three groups were computed. Both these groups were compared using a one-way ANOVA. Tukey's b test was used to examine multiple comparisons since P values were found to be statistically significant in each of the three groups. Alpha values were set at 0.05 for all two-sided testing. Tukey's HSD test and post hoc tests were used to statistically assess the variation in the experimental groups' mean bond strengths. Comparisons of two self-etch adhesives with various solvents showed that their mean bond strengths varied, and the difference between the three groups was statistically significant ($P<0.05$).

Table 2: Experimental Groups' Mean Shear Bond Strength and Debonding Force

Group	Mean Debonding Force (N)	Mean Shear Bond Strength (MPa)
Renew MDP	86.2	18.41
Clearfil SE Bond	88.8	18.98

Discussion

The present in-vitro study compared the shear bond strength of two MDP-based Adhesives-Renew MDP (Prevest DenPro) and Clearfil SE Bond (Kuraray Noritake)—to dentin. Although Clearfil SE Bond demonstrated a slightly higher mean shear bond strength than Renew MDP, the difference was not statistically or clinically significant, suggesting that both adhesives perform similarly under standardized laboratory conditions. The importance of functional monomers like MDP in adhesive systems has been well documented. MDP's ability to chemically bond to hydroxyapatite enhances the stability and durability of adhesive interfaces.[11] This study's findings reinforce the notion that adhesives containing MDP can produce clinically acceptable bond strengths. The performance of Clearfil SE Bond, considered a gold standard among self-etch adhesives, has been validated in numerous studies for its reliable bond durability.[12]Interestingly, Renew MDP, despite being a newer product, exhibited bond strength values comparable to Clearfil SE Bond. This result suggests that advancements in adhesive formulations have begun to bridge the gap between newer and well-established materials. It has been shown that other factors such as the quality of polymerization, solvent type, and filler loading significantly influence the adhesive performance.[13,14]The slight difference observed could be attributed to variations in composition. Clearfil SE Bond contains colloidal silica fillers, contributing to enhanced mechanical properties and reduced polymerization shrinkage.[15] Meanwhile, the newer Renew MDP may differ in its solvent system and filler content, which can subtly impact bond performance. The evaporation of solvents plays a critical role, as incomplete solvent removal can lead to compromised bond strength.[16]Another important consideration is the interaction between adhesives and dentin's collagen matrix. Studies have shown that MDP-based adhesives can better stabilize collagen fibrils against enzymatic degradation, improving long-term adhesion.[17] The similar results between Renew MDP and Clearfil SE Bond imply that both materials effectively interact with dentin substrates to form durable hybrid layers. Thermocycling and aging protocols, not performed in this study, could further reveal differences in long-term durability. Previous investigations have indicated that bond strength decreases significantly after artificial aging, especially in adhesives with inadequate collagen protection.[18,19] Future studies incorporating aging protocols could provide deeper insights into the comparative longevity of these two adhesives. Moreover, while tensile bond strength testing provides valuable information, it is influenced by testing parameters such as crosshead speed, specimen geometry, and storage media.[20] Although precautions were taken to standardize these factors in the present study, minor variations could still affect outcomes. In addition, recent research has emphasized the need for evaluation beyond bond strength alone, recommending nano-leakage assessments and molecular interfacial analysis to fully understand adhesive performance.[21,22] Such advanced investigations could differentiate materials that perform similarly in tensile testing but vary at the ultrastructural level. Finally, clinical factors such as operator variability, moisture control, and intraoral stresses must be considered when extrapolating in-vitro findings to clinical practice. A randomized controlled clinical trial would be the ideal next step to validate these adhesives' performance in real-world conditions.[23]

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