Original Research

Bond Durability of Dual Functional Monomers on Natural and Indirect Restorative Substrates

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A R T I C L E   I N F O

A B S T R A C T

Objective: To evaluate and compare the bond durability of a universal adhesive (Renew Universal, Prevest DenPro, India) and a gold-standard two-step self-etch adhesive (Clearfil SE, Kuraray, Japan) to enamel, dentin, zirconia, and nickel–chromium (Ni–Cr) alloy.

Materials and Methods: Ninety-six specimens (n = 24 per substrate) of enamel, dentin, zirconia and Ni–Cr alloy were prepared according to ISO standards. Enamel and dentin were etched with phosphoric acid and zirconia and Ni–Cr were airborne-particle abraded. Renew Universal and Clearfil SE adhesive were applied and composite cylinders bonded. Specimens underwent thermocycling (5000 cycles, 5–55 °C). Shear bond strength was tested using a universal testing machine. Data were analyzed with two-way ANOVA and Tukey's test ($\alpha = 0.05$).

Results: Enamel showed the highest bond strength in both groups (Renew Universal: 20.9 ± 2.3 MPa; Clearfil SE: 19.8 ± 2.1 MPa), while dentin showed the lowest (Renew Universal: 16.7 ± 2.0 MPa; Clearfil SE: 15.9 ± 1.8 MPa). Zirconia and Ni–Cr achieved intermediate values (Renew Universal: 18.2 ± 2.1 and 17.2 ± 1.9 MPa; Clearfil SE: 16.8 ± 2.0 and 15.7 ± 1.8 MPa, respectively). Thermocycling significantly reduced bond strength across all substrates ($p < 0.05$), but Renew Universal consistently outperformed Clearfil SE on zirconia and Ni–Cr ($p < 0.05$).

Conclusion: Renew Universal demonstrated effective bonding to tooth structure and indirect restorative substrates. Its dual functional monomers, 10-MDP and 4-META, enhanced adhesion to zirconia and Ni–Cr. However, aging significantly compromised bond durability.

Keywords: Universal adhesive, shear bond strength, enamel, dentin, zirconia, nickel–chromium, thermocycling.

Introduction

Achieving reliable and durable adhesion to both natural tooth substrates and indirect restorative materials remains a cornerstone of adhesive dentistry. Enamel, with its high mineral content, generally provides stable micromechanical retention after etching, while dentin poses greater challenges due to its tubular structure, organic composition, and higher susceptibility to hydrolytic degradation [1]. Contemporary adhesive systems are broadly categorized into etch-and-rinse, self-etch, and universal adhesives, each offering unique benefits and limitations [2]. Among self-etch systems, Clearfil SE Bond (Kuraray, Japan) has long been regarded as the "gold standard," owing to its mild self-etch primer containing 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate), which chemically bonds to hydroxyapatite and provides durable adhesion to enamel and dentin [3,4]. Its stable clinical performance over two decades has been confirmed in multiple randomized trials and systematic reviews [5,6]. However, limitations in Clearfil SE include its multi-step protocol and reduced bonding ability to indirect restorative materials such as zirconia and base metal alloys without additional primers [7]. To address these issues, universal adhesives have been developed, combining the versatility of multiple application modes with functional monomers to enhance adhesion across diverse substrates [8]. Renew Universal (Prevest DenPro,

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India) contains dual monomers—10-MDP and 4-META (4-methacryloxyethyl trimellitic anhydride)—designed to achieve both chemical bonding and improved wettability on metals and ceramics [9]. 10-MDP provides durable adhesion through stable MDP–Ca salts in dentin and MDP–ZrO_2 bonds in zirconia [10], whereas 4-META enhances interaction with metal oxide surfaces, improving bonding to alloys such as Ni–Cr [11]. Despite advances, the long-term performance of universal adhesives remains debated. Thermocycling and water storage can significantly reduce resin–substrate bond strength, particularly at zirconia and metallic interfaces [12]. Furthermore, few studies have directly compared newer universal adhesives with Clearfil SE Bond, particularly across both natural tooth and indirect restorative substrates under standardized testing conditions. Therefore, this study aimed to compare the shear bond strength of Renew Universal and Clearfil SE to enamel, dentin, zirconia, and Ni–Cr, before and after thermocycling, to evaluate their relative bond durability.

Material and Methodology

The present in-vitro experimental study was designed in accordance with ISO/TS 11405:2015 and ISO 29022:2013 standards for adhesive bond testing, using a total of ninety-six specimens distributed equally among four substrates: enamel, dentin, yttrium-stabilized tetragonal zirconia polycrystal (Y-TZP) and nickel–chromium (Ni–Cr) alloy. Specimens were randomly allocated into two adhesive groups: Group 1: Renew Universal (Prevest Denpro, India) Group 2: Clearfil SE Bond (Kuraray,Japan). Extracted, non-carious human molars were disinfected in 0.1% thymol solution,

sectioned with a water-cooled diamond saw to expose flat enamel and mid-coronal dentin surfaces and embedded in autopolymerizing acrylic resin, with bonding surfaces standardized using 600-grit silicon carbide paper under running water for 60 s. Zirconia discs (14 mm diameter × 2 mm thickness) were cut from pre-sintered Y-TZP blocks, sintered according to the manufacturer's instructions, ground with 600-grit SiC paper, and ultrasonically cleaned in distilled water for 5 min. Ni–Cr alloy discs (14 mm × 2 mm) were cast, finished to 600-grit, and ultrasonically cleaned. Both zirconia and Ni–Cr specimens were surface treated with airborne-particle abrasion using 50 µm Al_2O_3 particles at 0.25–0.4 MPa from a distance of 10 mm for 15 s, followed by ultrasonic cleaning and air drying. Adhesives were applied according to manufacturers' protocols, rubbed actively for 20 s, gently air-thinned for 5 s, and light-cured for 20 s using an LED curing unit (irradiance >1000 mW/cm², verified with a radiometer). Resin composite build-ups were fabricated using a Teflon mold (3 mm diameter × 2 mm height), filled in one increment, covered with a Mylar strip, and light-cured for 20 s. All bonded specimens were stored in distilled water at 37 °C for 24 h; subsequently specimens were subjected to thermocycling for 5000 cycles between 5 °C and 55 °C with a dwell time of 20 s and transfer time of 5 s to simulate oral thermal stresses. Shear bond strength was determined using the notched-edge shear test in a universal testing machine, applying a shear load at the adhesive interface with a crosshead speed of 1 mm/min until failure, with bond strength expressed in MPa by dividing peak load (N) by the bonded area (mm²). Statistical analysis included two-way

ANOVA to evaluate the effects of substrate type and aging condition, with Tukey's post-hoc comparisons; significance level was set at α = 0.05.

Figure 1: Application of Renew Universal Bonding agent to sample

Figure 2: Sample with resin-composite build up ready

Results Table 1 shows the mean shear bond strength (MPa ± SD) of both adhesives before and after thermocycling.

Table 1. Shear bond strength of Renew Universal vs Clearfil SE to different substrates

Substrate	Renew Universal	Clearfil SE
Enamel	20.9Mpa ± 2.3	19.8Mpa ± 2.1
Dentin	16.7Mpa ± 2.0	15.9Mpa ± 1.8
Zirconia	18.2Mpa ± 2.1	16.8Mpa ± 2.0
Nickel–Chromium	17.2Mpa ± 1.9	15.7Mpa ± 1.8

After thermocycling, all groups demonstrated a reduction in bond strength values compared to the baseline, although the trend across substrates remained similar, with enamel showing the highest resistance and dentin the lowest. Statistical analysis using two-way ANOVA revealed that both substrate type and aging condition significantly influenced bond strength values ($p < 0.05$). Tukey's post-hoc test confirmed that enamel exhibited significantly higher bond strength compared to dentin ($p < 0.05$), whereas no statistically significant differences were observed between zirconia and nickel–chromium groups ($p > 0.05$).

Discussion

This study compared the bond durability of Renew Universal and Clearfil SE to natural and indirect restorative substrates. Consistent with prior findings, enamel yielded the highest bond strength values, while dentin exhibited the lowest [1,2]. The relatively weaker dentin adhesion reflects the susceptibility of resin–dentin interfaces to collagen degradation and hydrolytic breakdown [3]. Clearfil SE demonstrated strong performance on enamel and dentin, corroborating its reputation as the clinical gold standard among self-etch adhesives [4,5]. Its success has been attributed to the presence of 10-MDP, which chemically bonds to hydroxyapatite and promotes nano-layering at the interface [6]. However, consistent with earlier reports, its performance on zirconia and Ni–Cr was inferior to Renew Universal [7,8]. This can be explained by Clearfil SE's lack of additional functional monomers and the fact that its recommended clinical use often requires separate primers for non-tooth substrates [9]. Renew Universal, in contrast, provided significantly higher bond strengths to zirconia and Ni–Cr after thermocycling. This advantage is due to its dual

monomer composition (10-MDP + 4-META). While MDP forms stable zirconia bonds [10], 4-META improves resin wettability and chemically interacts with metal oxides, thereby reinforcing adhesion to base metal alloys [11,12]. These findings are

Comparison of Shear Bond Strength Renew Universal vs Clearfil SE
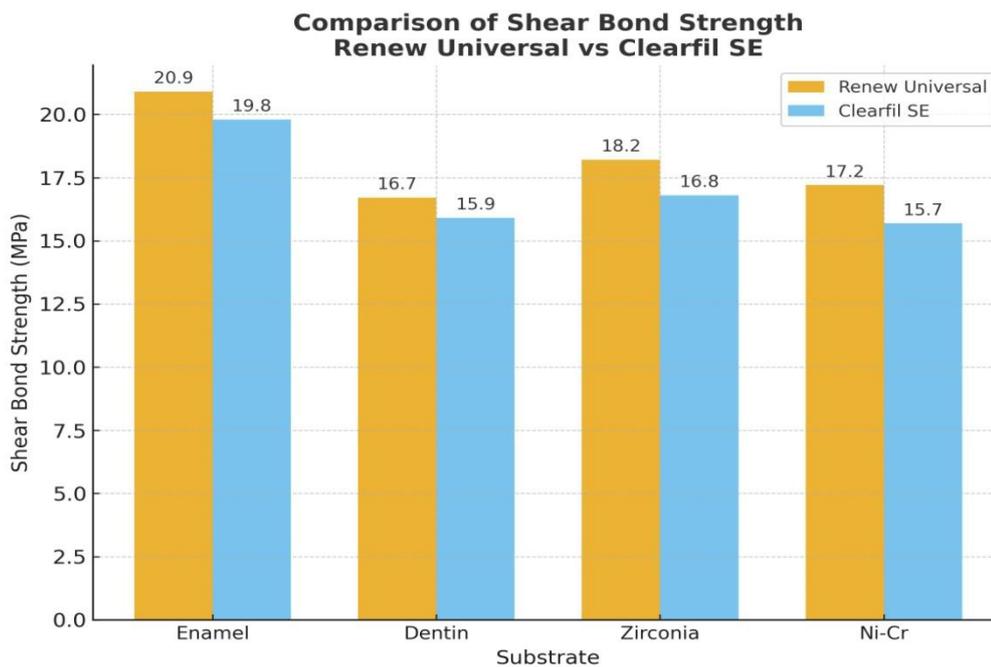
supported by Cooley and Burger [13] and Yamane et al. [14], who demonstrated enhanced metal adhesion with 4-META–based adhesives. Recent reviews also suggest that the synergistic combination of MDP and 4-META yields superior durability across diverse substrates compared with single-monomer adhesives [15]. Nonetheless, both adhesives showed reductions in bond strength after thermocycling, indicating hydrolytic degradation at the resin–substrate interface, particularly for zirconia and Ni–Cr [12]. Clinically, this underscores the need for supplementary strategies such as silane primers, universal primers, or additional surface conditioning when long-term stability is critical. Overall, Renew Universal showed broader substrate versatility, while Clearfil SE maintained reliable bonding to enamel and dentin. These findings suggest that adhesive selection may be guided by the specific clinical substrate: Both Clearfil SE and Renew Universal remains highly reliable for tooth structures, whereas Renew Universal demonstrates enhanced bonding to indirect restorative materials.

Conclusion

Within the limitations of this in-vitro study, it can be concluded that both adhesives exhibited substrate-dependent performance, with enamel showing the highest and dentin the lowest bond strength values. Thermocycling significantly reduced the bond strength across all groups, confirming the detrimental effect of aging on adhesive durability. Renew Universal (Prevest DenPro, India)

demonstrated higher bond strength than Clearfil SE (Kuraray, Japan), particularly on zirconia and nickel–chromium substrates, due to its dual functional monomers—10-MDP and 4-META—which enhanced chemical interaction with both tooth and indirect restorative materials. In contrast, Clearfil SE maintained reliable bonding to enamel and dentin but showed lower affinity for non-tooth substrates. The superior performance of Renew Universal on zirconia and Ni–Cr indicates its broader substrate compatibility and improved long-term bonding potential. Clinically, Renew Universal may be preferred for cases involving diverse substrates, whereas Clearfil SE remains a dependable choice for tooth structure.

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