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Effects of Mismatch Between Dentin Bonding Agents and Composite Resin on Shear Bond Strength of Composite Restoration: An in Vitro Study

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Abstract

Background: Adequate adhesion between the restorative material and its substrate, along with the integrity of the adhesive interface, is essential for the clinical success of restorations.

Objective: The purpose of the study was to evaluate the effect of using mismatched brands of bonding agents and restorative composite on shear bond strength of composite restoration, with emphasis on their interfacial compatibility.

Materials and Methods: Thirty sound human premolars extracted for orthodontic purpose were collected and equally divided into control and experimental groups. Samples in the control group were restored with composite resin and bonding agents of the same brands whereas samples in experimental group were restored with composite resin and bonding agents of different brands. Composite resins and bonding agents from three brands, SDI, Itena and Dentsply were used in the study. Specimens of both the groups were subjected to shear bond strength test using universal testing machine. Statistical analysis was performed using one-way ANOVA and post hoc Tukey test.

Results: Results showed significant difference in shear bond strength of control and experimental groups. High bond strength was manifested by samples restored with similar brands of composite resin and bonding agents and low bond strength was shown by samples restored with different brands.

Conclusion: Application of different brands of bonding agents and restorative composite adversely effects the bond strength of the restoration. Clinicians should incorporate using the right brand of prescribed bonding agents with matched composite resin in clinical practice to achieve optimal bonding performance and clinical outcomes.

Keywords: Dentin Bonding Agents, Self-etch Adhesives, Etch and Rinse Adhesives, Shear Bond Strength, Resin Dentin interface.

Introduction

Composite resins are considered the most aesthetic and promising tooth colour restorative materials involving minimal invasive procedure, but they lack the ability to bond naturally to the tooth structure.[1] Dental composite filling materials are bonded to enamel and dentin using resins known as bonding agents.[2] Adequate adhesion and bond strength of these bonding agents is crucial for clinical success of composite restorations.[3]

Adhesive systems and bonding techniques have been constantly evolving to achieve maximum bond strength and ease of use. These modifications include changes in chemical constituents, bonding mechanism and number steps involved in their application which impact their clinical effectiveness. [4] As a result, multiple generations of dentin adhesives are currently accessible in dentistry market. There are two major groups of resin based dentin bonding agents now available, self-etch adhesives and etch and rinse adhesives, based on their respective interactions with the substrate.[5] Depending on the primary steps of etching, priming and bonding to tooth substrate, dentin adhesives are presently available as 3-step etch and rinse adhesives (4th generation), 2-step etch and rinse adhesives (5th generation), two-step self-etch adhesives (6th generation) and one step self-etch adhesives (7th generation and 8th generation). Adhesive systems, irrespective of the number of bottles they are provided with, they all composed of similar basic constituents, although the percentage content varies between various classes.[6]

Bonding agents though constitute a minor portion of the bonded restorations, they are the crucial vulnerable point in the restoration. [7] The quality of adhesion between the adhesive resin, restorative material and tooth substrate can be assessed through parameters such as bond strength and marginal integrity. The most often used laboratory criterion to assess the efficacy of dentin adhesives is shear bond strength test.[8] Low shear bond strength is correlated with inadequate bonding whereas high shear bond strength indicates a durable bond. Adhesive bonding in dentistry is a mechanism that is influenced by a number of variables, such as kind of substrate, category of adhesive dentin adhesive, humidity of the environment and operator's skill in carrying out the bonding procedure.[9] One of the most important factor is the type of bonding agents used. Variations in composition and proportions among different brands and generations of bonding agents may influence their interaction with composite restorative materials and ultimately affect bond strength and marginal integrity.

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In Pakistan there appears to be widespread use of applying bonding agents of one brand with composite of another brand in dental practice. Using bonding agents of dissimilar brands can potentially influence the bond strength of such an interface. Therefore, it is essential to evaluate these variables to determine their influence on the bond strength of restorations involving mismatched adhesive and composite systems.

Materials and Methods

The study was carried out in Islamic International Dental College Islamabad, and Pakistan Council of Scientific and Industrial Research centre Peshawar. Ethical approval was granted by ethical board of KDC/IRC/2021/001/003 Islamabad. A total of thirty sound maxillary and mandibular premolars extracted for orthodontic purpose were used in the study. Samples were randomly divided into the control and experimental groups having fifteen samples in each group. Each main group was further subdivided into three subgroups, with five samples in each subgroup (n = 5). In the control group, bonding agents with same brands of composite resin were used. In experimental group, bonding gents were used with different brands of composite. The subgroups were arranged as follows:

Control group

Group A: Bonding of SDI adhesive with SDI composite
Group B: Bonding of Itena adhesive with Itena composite
Group C: Bonding of Dentsply adhesive with Dentsply composite

Experimental group

Group D: bonding of SDI adhesive with Itena composite
Group E: bonding of Itena adhesive with Dentsply composite
Group F: bonding of Dentsply adhesive with SDI composite

Table 1. Bonding agents and restorative composite used in the study

Bonding Agents	Class (Generation)	Restorative Composite
Stae, SDI	2-Step Etch and Rinse (5th Generation)	SDI Luna, nano-hybrid light-cured universal composite, Shade A2
Iperbond max, Itena	1-Step Self-etc (7th Generation)	Itena Reflectys, nano-reinforced micro-hybrid light cured composite, Shade A3
Prime & Bond Universal, Dentsply	1-Step Self-etch (8th generation)	Dentsply Sirona, nano-hybrid light-cured universal composite, Shade A2

Before preparation of samples, teeth were disinfected in 2.6% sodium hypochlorite solution. Plaque, pellicle and stains were removed from teeth using rubber cups and pumice powder slurry. Specimens were embedded in cold cure acrylic resin using teflon moulds having dimensions of 2.5 cm x 3.5 cm. The occlusal surfaces of the teeth were infixed so that it protruded barely above the acrylic resin.

All specimen preparation, bonding procedures and composite restorations were carried out by a single operator to standardize the technique and minimize operator-dependent variability in bonding performance.

To expose dentin, the buccal surfaces of the teeth were trimmed flat with diamond tapered fissure bur employing high speed hand piece with water spray. Specimens were assigned to control and experimental groups and subgroups respectively and acrylic blocks in every group were each painted with distinct colour for differentiation. Dentin adhesives were applied to the prepared dentin surfaces according to manufacturer's instructions.

For the SDI adhesive system (Stae, SDI; 5th generation etch-and-rinse), the enamel surface was etched with 37% phosphoric acid for 15 seconds, followed by rinsing with water for 10 seconds. The surface was then gently air dried. A sufficient amount of dentin adhesive was applied and gently air thinned until no freely moving liquid was visible. The adhesive was subsequently light cured for 10 seconds. For the Iperbond Max adhesive (Itena; 7th generation self-etch), a sufficient amount of bonding agent was applied using a disposable applicator and actively brushed on the surface for 20 seconds. This was followed by gentle air drying for 5 seconds until no freely moving liquid was visible. The bonding agent was then light cured for 10 seconds.

For the Prime & Bond Universal adhesive (Dentsply; 8th generation), the bonding agent was applied to the prepared surface for 20 seconds, followed by air drying for 10 seconds. The adhesive layer was then light cured for 10 seconds. Composite cylinder built-up was done in two increments using split Teflon moulds with dimensions 5mm x 3mm, followed by light curing. The split Teflon was removed and every single cylinder was light cured for additional 20 seconds at a light intensity of 500 mW/cm² using an LED curing light (Woodpecker LED curing unit, Guillin Woodpecker Medical Instrument Co., China).

Following that, all samples were kept in distilled water at room temperature for one day. Specimens were mounted on universal testing machine (AG-IS Shimadzu Japan) as shown in figure 1. Composite cylinder was located transversal and the shear blade was positioned perpendicular to the tooth restoration juncture. Force was applied at a cross head speed of 0.5mm/min. Each sample was loaded till it broke and shear forces were documented directly from computer software in megapascal MPa

Figure 1: Mounted samples in universal testing machine

Results

SPSS version 22 was used to conduct statistical analysis on the data. One-way ANOVA followed by post hoc Tukey testing was used to compare intergroup differences among the study groups.

According to the findings, mean shear bond strength scores of control groups (where bonding agent with similar brand of composite was used) i.e. group A (18.90 ±0.44), group B (15.83 ± 0.36) and Group C (13.03 ± 0.54), were higher as compared to mean shear bond strength values of the experimental groups (where bonding agents with dissimilar brands of composite resin was used) i.e. group D (14.98 ± 0.46), group E (12.36 ± 0.52) and group F (10.32 ± 0.31).

Table 2. Shear bond strength values of different study groups (in mega Pascal)

	Sbs Values In The Study Groups (in Mpa)				
Group A	18.73	19.09	18.34	19.55	18.83
Group B	15.35	15.59	16.08	16.25	16.25
Group C	12.89	12.30	12.94	13.26	13.79
Group D	15.69	14.79	14.93	15.10	14.43
Group E	13.19	12.46	11.93	12.38	11.88
Group F	10.40	9.97	10.44	10.76	10.06

One-way ANOVA demonstrated a statistically significant difference in shear bond strength among all the groups ($p < 0.001$). Post hoc Tukey analysis indicated significant intergroup differences, except between Groups B and C, and Groups D and E.

Table 3. Descriptive statistics of shear bond strength corresponding to all the sub-groups

Group Type	Mean	Standard Deviation	Standard Error of Means	Mean Deviation
Group A	18.90	0.44	0.20	3.92
Group D	14.98	0.46	0.20	
Group B	15.83	0.36	0.16	3.46
Group E	12.36	0.52	0.23	
Group C	13.03	0.54	0.24	2.71
Group F	10.32	0.31	0.14	

The results indicate that when teeth were restored using varying brands of bonding agents and composite resin, there appeared a marked decrease in shear bond strength of the restoration.

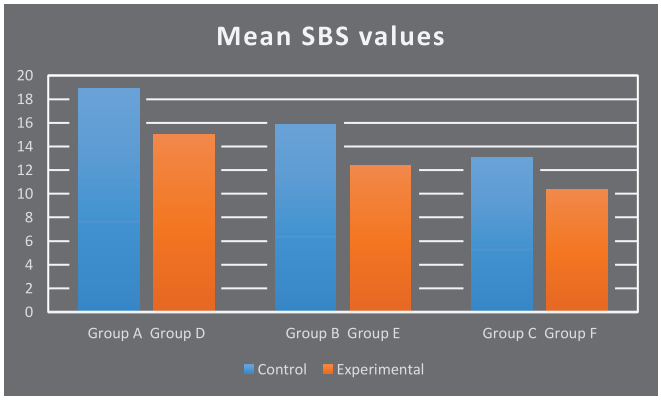

Figure. 2 mean shear bond strength values of study groups

In the light of results, highest mean shear bond strength value was observed in 5th generation etch and rinse (Stae SDI) bonding agent (18.90 ± 0.44), followed by 7th generation self-etch adhesive (Iperbond max) bonding agent (15.83 ± 0.36) and least Shear bond strength value was noted in 8th generation (Prime and Bond, Dentsply) bonding agent (13.03 ± 0.54).

Discussion

Although bonding agents have advanced significantly, each adjustment does entail new chemical formulations and can occasionally have a significant impact on the mechanism of bonding.[4] Changes in dental adhesive composition by different brands, influences materials' key physical and chemical properties and consequently the bonding efficacy of the adhesives.

Significant disparities in bond strength statistics are reported in the literature which are considered to be caused by variations in test protocols.[7] A number of variables impact in vitro bond strength to dentin, including tooth type and age, extent of dentin mineralization, the dentin surface being bonded, the type of bond strength test (shear or tensile), moisture content in substrates, the complexity of the testing approach, the vulnerability of processing and manipulation of the systems in question, and composite material.[10]

In the present in vitro study, the influence of mismatch between bonding agents and composite restoration on shear bond was assessed using shear bond strength test procedure in universal testing machine. The samples restored with similar brands of composite and bonding agents were taken as control, and the specimens restored with different brands of composite resin and bonding agents were included in the experimental group. The results showed a marked difference amongst all three groups of control and experimental groups.

P-value was distinctly significant i.e. *P*=0.0001 for inter group comparison between all the groups which indicates that bond strength of the samples markedly decreased when bonding agents were used with dissimilar brands of composite. The possible justification for this could be the varying components of dental adhesives and composite formulations of different manufacturing brands. As mentioned earlier, for strong interaction and covalent bonding between the bonding agent and the overlying composite, the adhesive and the composite resin must have similar basic monomer.[11] Monomers ought to be regarded as the most crucial elements of dental adhesives because they serve as the foundation for the material, ensuring structural consistency and consequently, physical and chemical qualities like bond strength.[12] Changes in the chemical makeup of dental adhesives affect essential qualities such as the rate and degree of conversion, water absorption, solubility, strength and bio-compatibility with the substrate.[13] Papadogniannis et al in their research study, used six different brands of universal adhesives and tested these bonding agents for shear bond strength and Vickers microhardness. They concluded from their research that although all the adhesives used in their study were based on 10-methacryloyloxydecyl Di-Hydrogen phosphate (10-MDP) adhesive monomer, the different co-monomers, solvents and catalysts led to variations in their film properties, reactivity and bonding capacity with dentin.[14] These findings correlate well with results of our study where differences in chemical ingredients of different brands of composite resin and bonding agents led to marked decrease in shear bond strength and marginal integrity of the tooth-restoration interface.

The increased bond strength of 5th generation adhesives may be attributed to formation of longer resin tags, deeper extension of resin through the etched surface and creation of a thick hybrid layer as observed by Kanniappan et al in their research analysis of smear layer, hybrid layer and resin tag formation.[15] The ingredients in different brand formulations also impact the interface properties of the materials such as bond strength. The presence of acetone solvent in Stae (SDI) formulations prevents esterification of carboxylic acid groups, thereby improving demineralization and enhancing wetting.[10] Acetone also has good water chasing capacity.[16]

A number of reasons may contribute to the lower bond strength of self-etch adhesives. Simplified adhesives with intricate formulations and high solvent contents may not completely volatilize their solvents, which would result in worse adhesive polymerization.[17] It is widely acknowledged that simplified adhesives have inferior in vivo lifespan and poorer in vitro durability outcomes of the restoration.[18]

Universal adhesives constitute a blend of hydrophilic, hydrophobic, and neutral character monomers. 8th generation bonding agents are mild SEAs that demineralize dentin to a depth of 1µm enabling remaining hydroxyl apatite adhered to collagen. The submicron hybrid layer's retention of hydroxyl apatite functions as receivers for further chemical bonding.[19] Improved bonding power in new generations of self-etch bonding agents may be caused by nanoscale cross-linking silica fumes.[20] This data seems to correlate well with our findings in which 7th generation (Iperbond max, Irena) have fumed silica in its composition and has shown increased shear bond strength value than the 8th generation (Prime and Bond, Dentsply) universal adhesive. Another possible reason for high

bond strength of samples restored with Itena composite and bonding agent may be due high filler content in Itena Reflects composite (up to 80%) as compared to Sirona Dentsply (up to 77%).

There are many reports that have analysed the bond strength and marginal integrity of different classes and generations of dental adhesives. However to the investigator's knowledge, there are no reported studies to date that have assessed the influence of using mismatched bonding agents and composite restorative material on bond strength and marginal integrity. Within the limitations of this in vitro study, the use of mismatched brands of bonding agents and composite resins was associated with a significant reduction in bond strength at the adhesive interface. These findings highlight the potential adverse impact of such combinations in clinical practice. One limitation of this study is the absence of SEM analysis, which could have helped characterize the mode of failure (adhesive versus cohesive) and provided a deeper understanding of interfacial bonding mechanisms. Further studies incorporating aging protocols and SEM evaluation are recommended to assess long-term performance and to better elucidate the effects of using mismatched adhesive and composite systems.

There is a requirement for a clinical study to verify whether or not the mismatching has a negative impact on direct composite restorations in patients' mouth. There is also a requisite for comprehensive chemical analysis of constituents in formulations of different brands to find out how they negatively influence the interface properties of bonded restorations.

Conclusion

The findings of our study suggest that application of different brands of bonding agents and restorative composite adversely effects the bond strength of the restoration. Clinicians should prioritize the use of compatible bonding agents and composite resins from the same manufacturer to ensure optimal bonding performance and achieve favorable clinical outcomes. Further research and clinical trials are required to substantiate these results and strengthen the evidence base for clinical application.

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Author Contributions

1. **Sughra Abid:** Study design, Data collection and processing, Literature review, and Article writing.
2. **Uzma Hassan:** Literature review.
3. **Amna Arif:** Article writing.
4. **Sahibzada Ammar:** Analysis and interpretation of results.
5. **Saira Ikram:** Provision of materials, biological samples, and referred patients.
6. **Aiman Khan:** Critical review of the manuscript.