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Comparative evaluation of shear bond strength of universal bonding agent and total-etch bonding agent on superficial and deep dentin: An in vitro study

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***Abstract*---**Background: To conserve the tooth structure, bonded restorations are popular nowadays. Bonding to enamel is predictable by acid-etch technique. However, bonding to dentin remains a challenge. Aim: To determine the better bonding agent between universal bonding agent and total-etch bonding agents based on shear bond strength using universal testing machine. Methodology: Eighteen human permanent mandibular molars were sectioned longitudinally to obtain thirty-six samples. Samples were randomly divided into three groups according to the bonding agent, Group A (Unbonded), Group B (Universal bonding agent) which was again divided into

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Subgroup B1 (Superficial dentin), Subgroup B2 (Deep dentin) and Group C (total-etch bonding agent) which was again divided into Subgroup c1 (Superficial dentin), Subgroup c2 (Deep dentin). Composite block was built up and samples were mounted in acrylic resin. Thermocycling was done and then samples were subjected to Universal testing machine. Statistical Analysis: The data was analysed using One-way ANOVA and Post hoc tests. Result: Universal bonding agent showed higher mean shear bond strength than total-etch bonding agent at both superficial and deep dentin level. Conclusion: The shear bond strengths of Universal Bonding agent and total-etch bonding agents were affected by the dentin level i.e., superficial and deep dentin. Universal bonding agent showed better shear bond strength at superficial and deep dentin levels.

***Keywords*---**universal bonding agent, total-etch bonding agent, permanent mandibular.

Introduction

The use of adhesive procedures for tooth repair has widened the scope of aesthetic dentistry. The modern method of tooth preparation focuses on achieving a more conservative cavity design, thus allowing for total excision of the carious tissue. The restorative treatment is based on the bonding ability of adhesive materials such as resin composites, which do not necessitate the removal of healthy tooth structure for extra mechanical retention[1].

Buonoccore pioneered the acid etching technique in 1955. Enamel adhesion has been largely successful since then. The micro mechanical interface of bonding agent with enamel is caused by the diffusion and interlinking of resin monomers into the microporosities left dissolving of enamel. Bonding to enamel after phosphoric acid etching is the cornerstone for the strength of bonding restorative procedures.

It's much more difficult to bond to dentin than it is to bond to enamel. It is distinguished from enamel by the presence of a smear layer, organic substances, and fluid within the dentinal tubules. Inorganic stuff makes up only 45 percent of dentin. Dentin bonding has always been a difficulty for clinicians because to its inherent complicated morphological structure of nanometre-sized carbonate-rich apatite crystallites scattered between strongly mineralized collagen impoverished hollow cylinders[2].

Along with the complex histology of dentin, its composition and permeability also differ in depth from region to region of the tooth. The majority of the bond strength will be provided by superficial dentin, which has fewer tubules, and resin absorption into intertubular dentin. Because the number of dentinal tubules is higher in deep dentin, resin intratubular permeability will be responsible for greater bond strength. Above the pulp horns, occlusal dentin permeability is also higher than in the middle of the occlusal surface. Proximal dentin allows more

fluid to pass through than occlusal dentin, while coronal dentin allows more fluid to pass through than root dentin[2].

To achieve a good bond strength to dentin, various generations of dentin bonding agents were developed. In 2011, universal or multi-mode adhesives with acidulated monomer MDP were launched, providing better adherence to enamel and higher bond stability to dentin[3]. Nano fillers improve enamel-dentin bonding strength, as well as stress absorption and shelf life[4]. Thus, these newly introduced bonding agents were compared against the traditionally used total-etch bonding agents which are considered a gold standard for enamel and dentin bonding.

Methodology

Eighteen human permanent mandibular second molars with sound roots and crowns extracted for periodontal reasons were collected. Teeth with dental caries, dentinal cracks and wearing diseases were excluded. With the use of an ultrasonic scaler, soft tissue remnants and debris were removed from the teeth, which were then kept in distilled water until needed. Collected eighteen teeth were sectioned using diamond disc, into two equal halves. The section was given longitudinally (buccolingually) to obtain 36 samples.

All the Samples were divided into 3 groups: -

- Group A: Control group (n=12)
- Group B: Universal bonding agent (n=12) : G-Premio bond manufactured by GC Corporation, Tokyo, Japan
- Group C: Total-etch bonding agent (n=12): Adper Single bond 2 manufactured by 3M ESPE, USA.

Group B and Group C were again divided into 2 subgroups each.

- Subgroup 1: Superficial Dentin (B1 n= 6, C1 n=6)
- Subgroup 2: Deep Dentin (B2 n=6, C2 n=6)

No subgroups were divided in group A. Superficial dentin level and deep dentin level were marked with a marker.

- Within 0.5-1 mm of the dentin enamel junction, superficial dentin (Subgroup B1 and Subgroup C1) was marked.
- Deep dentin (Subgroup B2 and C2) was identified immediately above the maximum pulp horn level.

A carborundum disc was used to split the samples at the indicated levels. For Group A, no sectioning was done. Bonding was done according to the manufacture's instructions. The use of a bonding agent was not used in Group A. The universal bonding agent GC G-Premio bond (GC) was employed for Group B. After applying 2-3 coats of bonding agent, the area was left as it is for 10 seconds. It was then completely dry for 5 seconds at maximum air pressure before being light cured for 10 seconds.

The etching for Group C was done by applying 37 percent phosphoric acid for 15 seconds and then rinsing it for 10 seconds. A cotton pellet was used to wipe

excess water. Using a completely saturated applicator, 2-3 coats of Adper Single Bond 2 (3M) were applied for 15 seconds with gentle agitation and gently air dried for five seconds.

Then, 2 mm composite block was built up on the samples of Group B and Group C using nanohybrid composite. The height of the composite block was adjusted to 2 mm, the length (buccolingual) was adjusted to 8mm and width (mesiodistal) was adjusted to 4mm (Figure 1).

After that, the samples were placed in acrylic resin blocks with the resin-dentin contact left out for force application. All of the samples were subjected to 500 thermocycling cycles in a water bath for 40 seconds range of 5 to 55 degrees Celsius temperature. The samples were next verified using a Universal Testing Machine (computerised, software-based) from ACME Engineers in Pune, with a speed of 1 mm/min.

The greatest shear bond force (Newton) was measured when the restorative material fractured (de-bonded). The shear bond strength in Megapascals was considered by dividing the force by the area.

Results

SPSS (v.21.0) statistical software was used to conduct descriptive and inferential statistical analysis. The significance level was set at 0.05. For comparisons between the two intervention groups in the study, an unpaired t-test was used by the researcher. Wherever possible, non-parametric tests were used. Table 1 showed that when all three groups were compared, Control group had the highest mean shear bond strength, followed by Universal bonding agent group and finally Total-etch group.

Using independent samples tests/unpaired t tests, the mean bond strength of different groups at the superficial and deep dentin was compared. There were statistically significant differences (p value 0.05) in this comparison. Table 2 showed that Group B1 had mean SBS considerably higher than Group C1($p = 0.03$), whereas Group B2 had SBS was significantly higher than Group C2 (p value 0.04). There was a statistically significant difference between the two groups.

Graph 1 depicts that, when the mean SBS of Group B1 & Group B2 were compared intragroup, the difference was statistically significant. In addition, while Group C1 showed larger mean SBS than Group C2.

Discussion

Bonding dentistry is becoming increasingly popular in order to preserve tooth structure. The notion of 'minimally intrusive dentistry,' developed by GV Black in 1917, is no longer justifiable and has been superseded by the concept of 'extension for prevention[5].

Due to acid etching technique and higher inorganic content of, enamel bonding is more predictable. However, dentin bonding is crucial. The intrinsic wetness of dentin, its tubular structure, the high organic content (more than 55 %) and the presence of smear layer after cutting of dentin contribute to the challenge on dentin bonding.

Furthermore, the percentage area occupied by dentinal tubules increases from the DEJ (about 20,000 per mm2) to the pulp (45,000 per mm2). Tubules occupy twenty two percent to twenty eight percent of the cross-sectional area near the pulp, but just one percent to four percent near the enamel[6], as per the specialists. As a result, more dentinal fluid is present in the deep layer of the dentin, and less inter-tubular dentin is available for bonding. According to several research, adhesive resin bond strengths are highest on superficial dentin and lowest on deep dentin.[7,8,9].

Similarly in the present study it was found that when intragroup comparison was done, Subgroup B1 showed higher mean SBS than Subgroup B2 and Subgroup C1 showed higher mean SBS than Subgroup C2 i.e., the superficial dentin subgroups showed higher mean SBS than mean dentin subgroups. As a result of this problem, a variety of bonding agents have been developed. Universal bonding agents have recently been in use. These were created to address the shortcomings of the previous generation, allowing for a total-etch or self-etch technique to achieve strong bonding in enamel and dentin tissue.

Intergroup comparison of mean shear bond strength of Universal bonding agent and Total-etch bonding agent at superficial and deep dentin showed that, Group B1 had higher mean value than C1(p value = 0.03) and Group B2 Showed higher mean value than C2 (p value =0.04) and the difference was statistically significant i.e., at both the dentin levels, Universal bonding agent performed better than total-etch bonding agent.

The alteration in performance is attributed to the changes in chemical composition of the two bonding agents. The level of acidity is a significant and essential distinction. The universal adhesive under test has an intermediate pH of 1.5 due to the 10-methacryloyloxydecyl dihydrogen phosphate monomer (MDP). Because of their acidic pH, universal bonding chemicals dissolve the smear layer and demineralize the dentin, allowing them to enter into the demineralized dentin[10].

Suyama et al. discovered similar results when comparing the micro tensile bond strength of two self-etch adhesives, discovering that single-step self-etch bonding agents had a significantly lower bond strength to bur-cut dentin than to smear-

free dentin, with the exception of strong single-step self-etch adhesives with acidic pH[11].

10-MDP monomer is employed in universal adhesive systems due to its chemical affinity for hydroxyapatite, which is present in dentin tissue[12]. These systems also include BPDM, PENTA, and polyalkenoic acid copolymers, which can help in the attachment of tooth tissue[13].

The matrix structure of universal adhesive solutions is made up of a combination of hydrophilic HEMA, hydrophobic UDMA, and Bis-GMA monomers. As a result of the combination of these qualities, universal adhesives provide a bridge between hydrophilic dental tissue and hydrophobic composite resin under a variety of surface conditions[1]. MDP can bind to the hydroxyapatite in dentin and form chemical bonds. After demineralization, the remnant hydroxyapatite round the collagen fibrils acts as a receptor for chemical interaction with MDP, resulting in improved adhesive performance[14].

Moreover, the universal bonding agent used in this study contained nanosized silica fillers. Thus, it has shown higher bond strength amongst the tested groups. This was supported by a previous study by Joseph et al. which showed that the presence of nano sized cross-linking silica fillers are responsible for increased bond strength in the newly introduced universal generation bonding agents[15]. Also, in the present study it was observed that at the deep dentin level, Universal bonding agents performed better than the total-etch bonding agents even at the deep dentin level.

As discussed previously, deep dentin presents with a challenge to dentin bonding. Because universal bonding agent contain useful monomers with varying self-etching capacities, each monomer achieves micromechanical interlocking. Functional monomers like 10-MDP interact with hydroxyapatite of dentin to form 10-MDP-Ca salts, thus increasing the chemical interaction of the monomer with the dentin substrate which is not in case of functional monomers like glycerol phosphate Di methacrylate which are present in total-etch bonding agents[16].

In addition to this, universal bonding strategy eliminates the additional step of acid etching and thus reducing the margin of error. Also, universal adhesion mode does not remove smear layer or hybrid layer. Therefore, apatite crystals, smear layer remnants and collagen fibrils are available for bonding along with calcium ions, thus increasing the chemical interaction. The acidic functional monomer 10-MDP forms a chemical interaction with dentin through its phosphate group, which binds to the remaining calcium connected to collagen fibres[17].

Munoz et al observed that 10-MDP appears to sustain binding strength following artificial ageing with water, similar to the findings of this investigation. The production of a stable and water-resistant Ca-monomer salt by the interaction of 10-MDP and the Ca2+ ions of hydroxyapatite could be the cause of this effect. Because 10-MDP is a hydrophilic polymer, it contributes to the bond's longevity and water resistance[18].

Conclusion

Within the boundaries of this research work, it is concluded that:

- The shear bond strengths of Universal Bonding agent and total-etch bonding agents were affected by the dentin level i.e., superficial and deep dentin.
- Universal bonding agent showed better shear bond strength at superficial and deep dentin levels.

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Conflicts of interest
There are no conflicts of interest.

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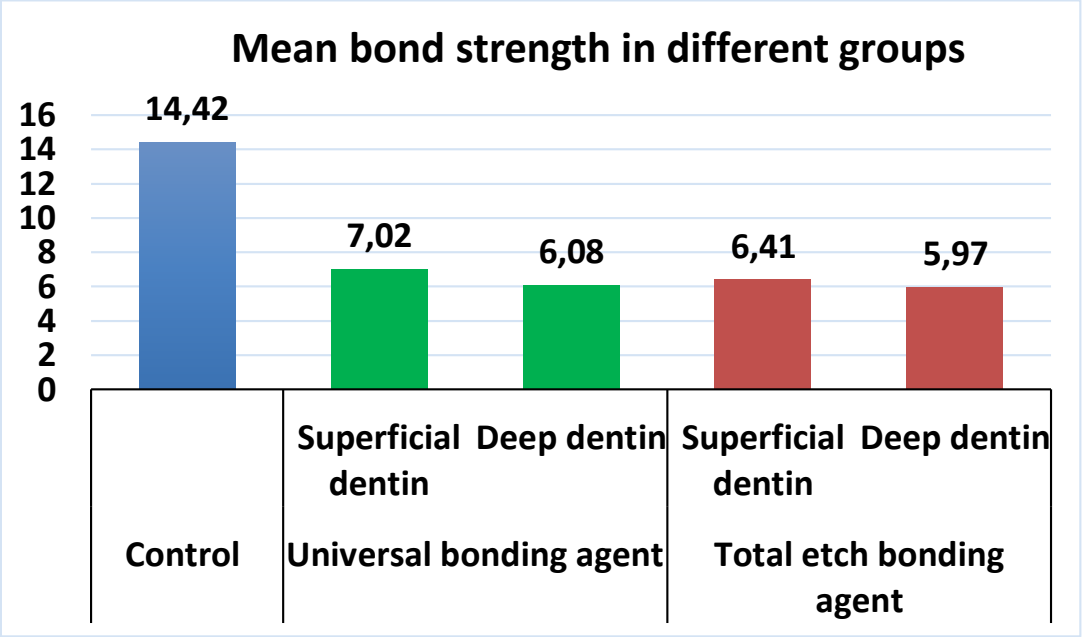
Tables and Graphs

TABLE 1: Comparison of mean Shear bond strength between Group A, B and C.

Groups	Subgroups	Mean	Std. Deviation
Control group (A)	-	14.42	5.32
Universal bonding agent (B)	Superficial dentin (B1)	7.02	1.53
	Deep dentin (B2)	6.08	2.1
Total etch bonding agent (C)	Superficial dentin (C1)	6.41	1.19
	Deep dentin (C2)	5.97	1.98

TABLE 2: Intergroup comparison of Mean bond strength of different groups at superficial dentin and deep dentin

Groups		Mean difference	df	t value	P value
Universal bonding agent vs Total etch bonding agent	Superficial dentin	0.61	5	1.221	0.03*
	Deep dentin	0.11	5	0.163	0.04*



Graph 1: Comparison of mean shear bond strength of Group A, B and C