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COMPARATIVE ANALYSIS OF ENAMEL BOND STRENGTH ANDMICROLEAKAGE OF 5TH AND7TH GENERATION BONDING AGENTS ON CUT AND UNCUT ENAMEL SURFACES

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ABSTRACT

Aims & Objectives: This study was designed to compare the 5th and 7th generation bonding agent's vis a vis tensile bond strength on cut and uncut enamel surfaces and microleakage in class V cavities prepared in enamel.

Material and methods: 60 extracted human mandibular molars were selected and randomly divided in to six groups. Four groups were used for tensile bond strength study, two groups each were bonded with 5th and 7th generation bonding agent on cut and uncut enamel surfaces and two groups were used for microleakage study. For microleakage study, class V cavities prepared on buccal surfaces were restored with 5th or 7th generation bonding agents. The restored teeth were stored in 100% humidity at 37 0 C for 24 hours and thermocycle between 5 0 C and 550 C for 100 cycles. Tensile bond strength was measured in Universal testing machine and microleakage was determined by dye penetration observed under stereomicroscope. The data were statistically analyzed.

Results: For both cut and uncut enamel surfaces, 5th generation bonding agent showed a significantly higher tensile bond strength value ($P<0.05$). No significant differences among the adhesives were found in terms of microleakage.

INTRODUCTION

The fundamentals of adhesive dentistry were first proposed by Buonocore in 1955, whoused industrial bonding methods to argue that acids can be exploited in surface treatmentprior to the application of resins.[1] He subsequently discovered that phosphoric acidetching of enamel lengthened adhesion under water.[2] The fundamental idea behind bonding to dental matrix is an exchange process in which synthetic resin is used toreplace the inorganic tooth material.[3] Although bonding to enamel could be accomplishedsuccessfully, bonding to dentin was extremely difficult because of its heterogeneousmakeup and water content. Smear layers and smear plugs were present, and this posed aserious issue because they prevented the dentin bonding agent from making direct contactwith the tooth surface. We now have bonding systems that can provide expected and stablejoining to both enamel and dentin with simple to use methods after going through anumber of generational advancements and overcoming early setbacks. One of dentistry'smost important developments in the 20th and 21st centuries was enamel bonding whichplays a significant role in most of the restorative procedures. They involve placingbraces, gluing ceramic veneers to etched enamel, extending class V restorations overbeveled coating surfaces, filling gaps with resin-based composites, and applying sealants.[4] Most of the times, the difference in bond strength between one bottle systems and self-etching primer remains comparable. Leakage tests performed in the lab and in real-world settings have demonstrated that one-bottle systems produce a better seal at the enamel margins than self-etching primer.[5,6] Sadly, despite the bonding products' simplification, worries about enamel bonds, substrate variability, and technique sensitivity have grown. A dissertation component, this study compares the performance ofthe newer, simpler 7th generation bonding system (i-Bond) to the 5th generation bonding system (Single Bond) on cut and uncut enamel surfaces.

Aims & Objectives

This study will be designed to compare the 5th and 7th generation bonding agents vis a vis tensile bond strength on cut and uncut enamel surfaces and micro leakage in class V cavities prepared in enamel.

Review of Literature

A simplistic approach of improving the bond between acrylic filling materials and enamelsurfaces was introduced by Michael Buonocore, who is regarded as the father of adhesivedentistry, in a paper published in 1955. 85% phosphoric acid was used by him to treat the enamel.[1]The adhesive acrylic resin material could bond to the detached teeth's dentin surface, and it was demonstrated in a study looking into the possibility of resin bonding to enamel that linkage or bonding potency could be roughly doubled with the help acid etching the dentinal surface. The connection was created by a chemical reaction betweena part of the adhesive system and the organic dentin substance. The resin was dimethaacrylate monomer with which phosphate groups were linked.[2] In a study on the connection between the achieved bond strength and the etch patterns caused by phosphoric acid on surface enamel. There was no discernible differences between the etch types on the lower and upper teeth. Albeit, the individual's teeth in the lower and upper arches did, however, statistically differ significantly from one another. They came to the conclusion that even without the perfect etch pattern, a strong bond could still be produced.[7] Along with examining the effectiveness of enamel etchants less potent than 10% phosphoric acid, researchers also looked at the relationship between the penetration depth and TBS(total bond strength) of a photo-cured resin to enamel that has been etched with phosphoric acid. They discovered that the length of the tags made by the tested photo-cured resin on enamel that had been etched with phosphoric acid had little to no impact on the binding effectiveness of test specimens. Any potential harm to enamel substrates might be reduced by using less aggressive acid concentrations.[8] A study looked into whether traditional mid-grit diamond bur and 600 grit Si C paper preparation techniques, which were used as controls, generate comparable enamel/dentine surfaces that are as amenable to bonding as various surface treatments such as diamond sono-abrasion, air-abrasion, and Er: exposure to YAG laser energy. It was established that employing an etch-and- rinse adhesive still requires separate acid etching of enamel and dentin surfaces that have been air-abraded and exposed to Er: YAG laser radiation. Dentin and enamel surfaces' bonding prepared by diamond sono abrading and air abrading was generally similar to bonding to surfaces prepared by conventional diamond burs, whereas bonding to surfaces prepared by Er: YAG laser irradiation generally resulted in a significantly lower bonding effectiveness than surfaces prepared by diamond burs.[9] In a study, (μ TBS) of one- bottle adhesive systems based on ethanol/water and acetone to enamel and dentin was examined in the presence and absence of the corresponding solvents. The mean bond strength between the groups restored with and without an enamel solvent did not differ statistically significantly between them, it was noted. The lack of solvents in the adhesive systems, however, had a considerable impact on the microtensille bond potency (μ TBS) to dentin.[10]A research investigated the assertions that the resin-enamel bond strength varies by location and that the relationship between the bond potency and affixed cross- sectional area is inverse? These adhesive systems included Scotch bond Multipurpose and Clearfil Liner Bond II. The highest bond strength measurements of binding strength in the occlusal third were much greater than those to cervical enamel. This is most likely because fewer interfacial stress raisers are used in smaller samples.[11]Through shear bond strength and micro leakage; a study compared the efficacy of two acidic primers for bonding to enamel and dentin with and without etching. Maleic acid was present in one of the acidic primerswhile Phenyl-P was present in the other. It was discovered that the acidic primer containing Phenyl-P could be applied to enamel and dentin without the need for an etching step,but the primer containing maleic acid needed to beapplied with an etching step.[12]An overview of the parts and polymer chemistry features of the self- etching enamel-dentin adhesives now in use. Additionally, the improvement in single bottle adhesive performance brought on by novel adhesive's monomers and traverse linkers with greater hydrolytic moisten stability over methacrylate is examined. It was determined that morereliable andsuitable components must be produced in the future. Utilizing contemporary acrylicether phosphate acids or mono- or difunctional acrylamides will boost the durability of self-etching enamel-dentin adhesives.

When N-acryloyl aspartic acid concentration reached 20 wt%, the binding tensile vigor to enamel grew linearly with increasing the acid intensity, reaching the equivalent value of 40 wt% as with enamel etched phosphoric acid with the benefit of skipping the rinse step with water.[14] In a study to evaluate the enamel microtensile bonding power of five couples of enamel adhesives from the same manufacturer, it was found that some total-etch adhesives performs excellently well in connecting to enamel as compared with equivalent self-etch adhesives. The use of a diamond bur to roughen enamel sparked a trend for self-etch adhesives with a stronger adhesion.[15]

Material and methods:

60 freshly extracted mandibular molars with unattrited, intact crowns free from decay andfractures were collected from Department of Oral and Maxillofacial Surgery, Teeth were scaled with Ultrasonic scaler toremove tissue tags, plaque and calculus and they were polished with pumice and stored inphysiologic saline till used. They were randomly divided in to 6 groups of 10 teeth each.

Group I: Uncut teeth - Application of 5th generation bonding agent (Single Bond) for tensile bond strength test.

Group II: Uncut teeth - Application of 7th generation bonding agent (iBond) for tensile bond strength test.

Group III: Teeth with cut superficial enamel surfaces - Application of 5th generation bonding agent (Single Bond) for tensile bond strength test.

Group IV: Teeth with cut superficial enamel surfaces - Application of 7th generation bonding agent (iBond) for tensile bond strength test.

- Six sets of 60 extracted human mandibular molars will be chosen at random. Two groups each will be bonded using 5th and 7th generation adhering agents on cut/uncut enamel surfaces, and four groups total will be employed for the TBS investigation. ClassV cavities that have been constructed on buccal surfaces will be repaired using 5th or 7th generation bonding agents to conduct a microleakage investigation. The apices of theteeth should be sealed **with Glass ionomer cement to** avoid dye penetration from the root canal.

- Teeth will be sectioned bucco-lingually in to mesial and distal halves using lathe mounted carborundum discs. Mesial and distal sections of one tooth will be consideredsimilar. So both mesial and distal section will viewed under stereomicroscope with 40x magnification and microleakage was scored depending on the degree of dye penetration.

The recovered teeth will undergo a 100-cycle thermocycle between 0°C and 550°C at 37°C and 100% humidity for24 hours. Universal testing equipment will be used to assess the tensile bond strength, and a stereomicroscope will be used to measure the amount of microleakage.

Microleakage measurement was done according to the penetration of dye along the tooth-restoration interface.

0 = No leakage.

1 = Dye penetration less than half way to the axial wall.

2 = Dye penetration greater than half way to the axial wall.

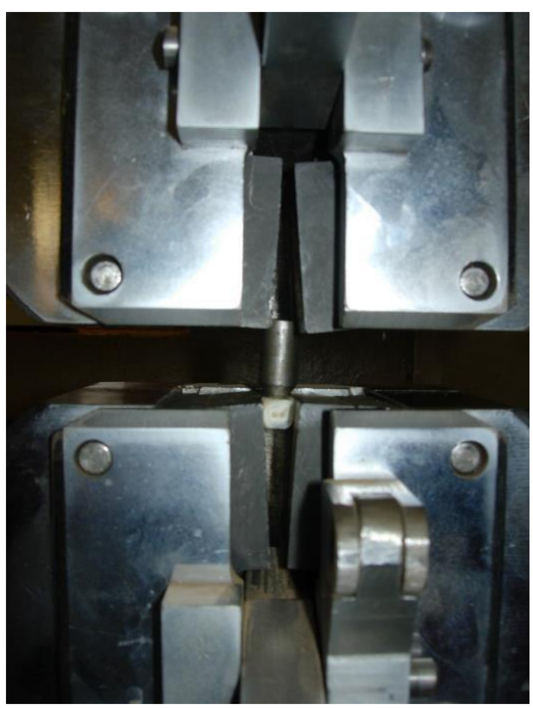
3 = Dye penetration along the axial wall.

Figure 1. Armamentarium for tensile bond strength study

Figure 2. Universal testing machine.

Figure 3. Computer attached to universal testing machine

Figure 4. Tensile bond strength testing



Statistical Analysis

For quantitative data, the mean, SD, SEM, and range values will be shown. For comparisons between more than one group, a one-way analysis of variance will beemployed, supervened by a pairwise comparison using an unpaired t-test. Mann-whitney test will be utilized to determine any significant difference between the two groups since microleakage will be evaluated using scores, a non-parametric approach. A "p" value of 0.05 or less will be used for each test to indicate statistical significance.

RESULTS

This study was performed to evaluate the efficacy of “all in one” single bottle 7th generation bonding agent - iBond , when used on enamel surfaces as compared to 5th generation “etch and rinse” bonding agent - SingleBond. The efficacy was evaluated based on tensile bond strength test (Figure4). Microleakage was also assessed on class V cavities prepared on enamel only (Figure 7).In this vitro study, a total of 60 extracted permanent mandibular molars were used. 10 each were assigned to 6 groups. 4 groups were utilized for tensile bond strength test and two groups were utilized for microleakage test.

The mean bond strength values and standard deviation of Group I to Group IV areshown in the Table 5. Bond strength values were obtained in Kilo Newtons and were converted to Megapascals.

Comparison between the groups were made using one way ANOVA and Student’s unpaired ‘t’ test.

The results of comparison of enamel bond strengths between Group I and Group III are shown in the Table 6. The mean bond strength values of Group I are 4.94 ± 0.83 MPa (table 8) and for Group III are 3.62 ± 1.56 MPa (table 10). P value for comparison between Group I and Group III is 0.03 which is less than 0.05 indicating the statistically significant difference between the groups. This indicated that SingleBond is more efficient on uncut enamel surfaces compared to iBond.

The results of comparison of enamel bond strengths between Group II and Group IV are shown in the Table 7. The mean bond strength values of Group II are 25.44 ± 5.25 Mpa (Table 9) andfor Group IV are 8.51 ± 2.45 Mpa (Table 11). P value for comparison between Group II and Group IV is 0.001 which is less than 0.05 indicating highly statistically significant difference between the groups. This indicated that SingleBond is more efficient on cut enamel surfaces comparedto iBond.

Since microleakage was assessed by scores (Table 12), a non-parametric procedure, Mann-whitney test was used to find out any significant difference between thetwo groups. The percentage distribution for,

Score 0: Group V- 20%, Group VI- 30%.

Score 1: Group V- 60%, Group VI- 60%.

Score 2: Group V- 20%, Group VI- 10%.

Mean score

GROUPS	**SAMPLES**	**ENAMEL BOND STRENGTH (MPa)**			
		RANGE	**MEAN**	**SD**	**SE**
I	10	3.87-6.19	4.94	0.83	0.26
II	10	17.29-35.39	25.44	5.25	1.66

Standard deviation

Group V- 1.0 ± 0.7.

Group VI - 0.8 ± 0.6 (Table 13).

There was no significant difference seen between the Group V and Group VI.

The results indicated almost similar efficiency of SingleBond and iBond in preventingmicroleakage.

Comparison of enamel bond strength of group I andgroup III

Unpaired T- test I > III

P < 0.05, significant

GROUP	**BOND STRENGTH (MPa)**		**DIFFERENCE BETWEEN GROUP I & GROUP III**		
	MEAN	**SD**	**MEAN DIFFERENCE**	**t- VALUE**	**P-VALUE**
I	4.94	0.83	1.32	2.36	0.03
III	3.62	1.56			

Comparison of enamel bond strength of group I andgroup III

Unpaired T- test I > III

P < 0.05, significant

GROUP	**BOND STRENGTH (MPa)**		**DIFFERENCE BETWEEN GROUP I & GROUP III**		
	MEAN	**SD**	**MEAN DIFFERENCE**	**t- VALUE**	**P-VALUE**
I	4.94	0.83	1.32	2.36	0.03
III	3.62	1.56			

Comparison of enamel bond strength of group I I and group IV

MEAN	STANDARD DEVIATION	DIFFERENCE BETWEEN II & IV		
		MEAN DIFFERENCE	t- VALUE*	p- VALUE
25.44	5.25	16.91	9.25	< 0.001
8.51	2.45			

Enamel bond strength of single bond on uncutsurfaces (mpa)

GROUP I

SAMPLE	BOND STRENGTH (MPa)	MEAN
1	4.014	4.94
2	5.63	
3	4.41	
4	3.17	
5	4.86	
6	5.82	
7	3.87	
8	5.42	
9	6.19	
10	4.014	

Enamel bond strength of single bond on cutsurfaces (mpa)

GROUP II

SAMPLE	BOND STRENGTH (MPa)	MEAN
1	17.29	25.44
2	35.39	
3	23.07	
4	25.00	
5	23.59	
6	21.65	
7	23.03	
8	31.33	
9	24.44	
10	29.58	

Enamel bond strength of ibond on uncut surface (mpa)

GROUP III

SAMPLE	BOND STRENGTH (MPa)	MEAN
1	1.94	3.62
2	2.11	
3	1.06	
4	3.31	
5	3.03	
6	4.86	
7	4.44	
8	5.82	
9	4.97	
10	4.65	

Enamel bond strength of ibond on cut surfaces (mpa)
GROUP IV

SAMPLE	BOND STRENGTH (MPa)	MEAN
1	6.69	8.51
2	4.06	
3	7.58	
4	9.55/ 11.62	
5	11.62	
6	12.32	
7	9.15	
8	6.83	
9	7.75	

10	9.51	

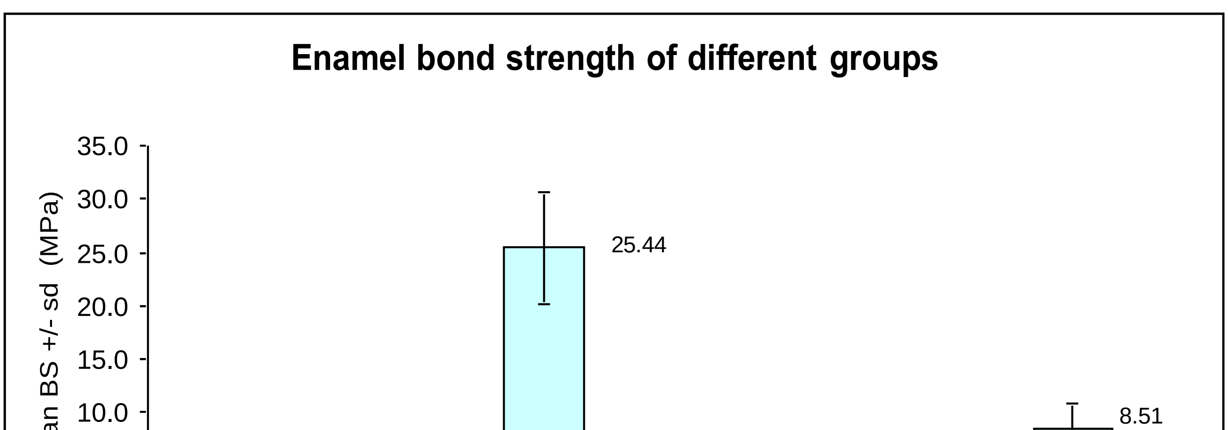
TABLE 12.MICROLEAKAGE SCORES

Samples	Group V	Group VI
1	2	1
2	2	0
3	1	0
4	1	0
5	1	1
6	0	1
7	1	1
8	0	2
9	1	1
10	1	1

Distribution of samples with correspondingmcroleakage scores.

GROUPS	SAMPLE	MICOLEAKAGE SCORES				MEAN SCORE ± STANDARD DEVIATION
		0	**1**	**2**		
V	10	2	6	2		1.0 ± 0.7
VI	10	3	6	1		0.8 ± 0.6

Chart 1



DISCUSSION

The widespread demand for, and use of dental adhesives has fueled an intense development of better and easier dental adhesives in rapid succession and dentists have literally been inundated with successive "generations" of adhesive materials. While the term "generations" has no scientific basis in the realm of dental adhesives, and is to a great extent arbitrary, it has served as useful purpose in organizing the myriad of materials in-to more comprehensible categories. The "generational" definitions help in identification of chemistries involved, the strength of dentinal bond and the ease of use for the practitioner.[6]

The present study, compares "iBond" -7th generation self-etching adhesive characterized by single bottle system with "SingleBond"- 5th generation 'etch and rinse' adhesive.

The parameters chosen were tensile bond strength using universal testing machine and microleakage using dye penetration with the help of stereomicroscope. Both cut and uncut surfaces were used.

iBond has been chosen because it has been propagated by the manufacturer as a unique, all-in-one bottle system incorporating etching, priming, bonding in a single step and hence user friendly and time saving. It was thought necessary to supplement the data asregards its bond strength and ability to withstand microleakage, when compared to more established 'etch and rinse' approach of 5th generation bonding agent which have been successfully used over a significant period of time and are considered to be the benchmark against which newer systems should be compared.

The results pertaining to microleakage at the enamel-restoration interface resultedin no significant difference between the groups treated with iBond or SingleBond ($P>0.05$).This confirms the fact that magnitude of bond strengths is not an accurate predictor of the sealing ability.[38] An estimated shear bond strength of 17-21MPa has been proposed as the critical value needed to withstand the stresses of polymerization contraction of the composite material.[38, 49, 50] Since tensile bond strength was taken as the parameter in this study the above prescribed minimum shear bond strength values to counteract polymerization shrinkage and thus prevent microleakage may not be relevant to this study.

SUMMARY

Dental profession is striving to achieve good adhesion of resin composite to substrate through reliable bonding with less microleakage and restoration stability to satisfy the esthetic demands of the patients. Composite restorations are technique sensitive and have high failure rates mainly due to inadequate isolation and subsequent higher incidence of marginal leakage.

The rate of development of new dentin/enamel adhesives has been too rapid to allow for clinical evaluation of all materials. Laboratory tests have therefore been used to screen new adhesives for their ability to bond to enamel and dentin.

Studies have shown reliable bonding on enamel with total-etch adhesives. With the introduction of new simplified adhesive systems which are less technique sensitive, the focus is shifted to use those adhesive systems to bond to enamel.

CONCLUSION

Based on the results of this in vitro study the following conclusions were drawn.

Tensile bond strength of SingleBond was significantly higher compared to iBond onboth cut and uncut enamel surfaces.

Microleakage study did not result in any significant difference between the groupstreated with SingleBond and iBond and was not conclusive.

Results showed that there was statistically significant difference between SingleBond and iBond on both cut and uncut enamel surfaces indicating that SingleBond was more efficient on both the surfaces.

In microleakage study, there was no significant difference between the groups.

Further studies are required to evaluate the efficiency of iBond in different testing condition

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