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Bonding efficacy of 5th,6th,7th & 8th generation bonding agents on primary teeth

Bharti Sachdeva[1], Parminder Dua[2], Ritu Mangla[3], Harpreet Kaur[4], Swati Rana[5], Apra Butail[6]

(Department of Paedodontics, Himachal Institute of Dental Sciences, India)
(Department of Paedodontics, Himachal Institute of Dental Sciences, India)
(Department of Paedodontics, Himachal Institute of Dental Sciences, India)
(Department of Prosthodontics, Himachal Institute of Dental Sciences, India)
(Department of Paedodontics, Himachal Institute of Dental Sciences, India)
(Department of Paedodontics, Himachal Institute of Dental Sciences, India)

Abstract
Background: *The aim of the present study was to determine and compare the shear bond strength of fifth, sixth, seventh and eighth generation dentin bonding agents on primary teeth.*
Materials and Method: *Sixty extracted primary teeth were selected and assigned into four groups 1– fifth generation bonding agent (Tetric N Bond) (Total etch) (IVOCLAR), group 2– sixth generation (FL Bond II) (SHOFU), group 3– seventh generation (Tetric N Bond) (Self etch) (IVOCLAR) and group 4– eighth generation bonding agent (Tetric N Bond) (Universal) (IVOCLAR). With high speed handpiece coronal dentin was exposed. Selected dentin bonding agents were applied followed by composite restoration. All samples were saved in saline for 24 h and shear bond strength testing was done using universal testing machine.*
Statistical analysis: *The obtained data was tabulated and statistically analysed using, HSD Tukey test.*
Results*: Shear bond strength of eighth generation group showed significantly higher value (*$P < 0.001$*). There was no significant difference present between fifth, sixth and seventh generation dentin bonding agents in primary teeth.*
Conclusion: *The greatest mean shear bond strength to dentin of primary teeth was exhibited by eighth generation dentin bonding agent due to its less time, fewer steps and higher shear bond strength.*
Keywords*: Shear bond strength, primary teeth, self etch adhesive, total etch adhesive.*

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I. Introduction

Early childhood caries is common in children and quickly leads to the loss of tooth structure in primary maxillary anterior teeth.[1] For the restoration of carious primary teeth tooth-colored materials are widely used in paediatric dentistry. Composite resins are the most preferred and useful tooth colored material used in paediatric dentistry.[2]

Composite restorations are placed following pretreatment of the cavities with an adhesive system.[3] The degree of interface adhesion and chemical stability is critical for successful clinical use of any resin.[4]

The word adhesion is derived from the Latin word "adhaerere", which means to stick. Adhesion refers to the forces or energies between atoms or molecules at an interface that hold two phases together.[5] Bonding agents are used to promote adhesion between composite resin and dental structure.[6]

BUONOCORE introduced the concept of acid etching, i.e. chemically treating the enamel, to alter enamel surface characteristics and to allow for adhesion of acrylic resins to the enamel surface of the tooth.[7]

Acid etching of the enamel with 85% phosphoric acid produced microporosities in the enamel, allowing resin bonding via micromechanical retention.[8] This technique has also given way to total-etch techniques, in which both the enamel and dentin surfaces are acid conditioned to allow for resin adherence to both enamel and dentin surfaces.[7]

However, primary teeth are smaller in size, have thinner enamel and dentin and show a rapid spread of dental caries. Hence, less tooth structure is available for bonding of composite resin. In primary teeth, proper bonding steps should be followed for the success of composite restoration. Though bonding to the enamel could be effectively achieved due to its uniform composition (hydroxyapatite), but bonding to dentin presents a real challenge due its heterogenous nature and presence of water, smear layer, smear plugs, etc.[9]

From two different methods current adhesive systems obtain acceptable micromechanical retention between resin and dentin. The first method uses acid etch technique based on complete removal of the smear layer and demineralization of subsurface intact dentin.[7,8] Second method is based on slightly acidic monomers in which smear layer gets demineralised partially with underlying intact dentin, incorporating the demineralised smear layer remnants and using them as bonding substrate, called as self etch approach. There has been a trend to move from the original type of multicomponent bonding systems toward simplified, consolidated adhesive systems that are more user-friendly.[8,10]

Total etch adhesive can be two step adhesives or three step adhesives.[10] Presently the concept of "self-etch" adhesives was introduced in which the sixth generation bonding agents consists of acidic primer and bonding resin separately, while the seventh generation bonding agents are self etch adhesives with combination of etchant, primer, and bonding agent in one component and applied as a single step.[11]

Apart from the simpler steps, the mechanism of action of self etch adhesives is surface demineralization of dentin and synchronous diffusion of monomers into the resultant porosities. One-step systems simplify and reduces the bonding procedure which makes it favourable in clinical practice or in uncooperative children.[12]

With developments in biotechnology and materials science, nanotechnology is especially anticipated to impart advances in dentistry.[13] Nano adhesives are one of the greatest contributions of nano dentistry which contain nanosized fillers. These adhesives are the solutions with nano particles which prevent agglomeration thus producing high dentin bond strength, high stress absorption, longer shelf life, durable marginal seal and release of fluorides. Recently the manufacturer of nanofilled dentin adhesives (Tetric N Bond, Universal) has claimed it as eighth generation dentin bonding agent.[9]

In light of these developments, present in-vitro study was undertaken to investigate and compare the bonding efficacy of fifth, sixth, seventh and eighth generation bonding agents on primary teeth, since in-vitro laboratory bond strength testing is used as screening tool to understand and predict the clinical behaviour of new products in a short period of time and lesser cost.

II. Subjects & Methods

A total of sixty freshly extracted non carious human primary teeth were selected and polished with the slurry of pumice and water. Root portion of teeth were cut off with the help of diamond disc and only coronal portion were embedded in cold cure acrylic resin with the help of custom made metallic mould of dimension 2×1.5cm. Teeth were mounted horizontally. The labial surface of each tooth was reduced with high speed handpiece using 245 carbide bur under constant spray of water to expose flat surface of dentin.

Prepared samples were divided into four experimental groups. For identification purpose, each group's acrylic block were painted with different color.

Group 1: Fifteen primary teeth bonded using fifth generation bonding agent (pink color)

Group 2: Fifteen primary teeth bonded using sixth generation bonding agent (red color)

Group 3: Fifteen primary teeth bonded using seventh generation bonding agent (blue color)

Group 4: Fifteen primary teeth bonded using eighth generation bonding agent (black color)

Tooth surface were rinsed with distilled water and blotted dry. Bonding agents were applied according to manufacturer's instructions onto the surface with microbrush and light-cured via Light Emitting Diode. The composite resin were placed in a two layer increment using plastic mould and were light-cured for forty seconds. Each composite cylinder was also cured for an additional forty seconds. All specimens were stored in distilled water for 24 hours prior to shear bond testing.

Shear bond strength testing was done using a universal testing machine (INSTRON) which was available at Central Institute of Plastic Engineering & Technology, Amritsar. The specimens were attached to a modified device (custom made jig for micro shear testing) and subjected to a shear force in a universal testing machine at a crosshead speed of 1mm/min in a compression mode using blade parallel to adhesive dentin interface. Bond strength were calculated in MPa, where the applied force (N) was divided by stick cross-sectional area (mm^2). Universal testing machine is a very precise machine used for subjecting small size specimens for various tests. Each specimen was loaded until failure. Shear force required to debond specimen was recorded. Data so obtained were tabulated and analyzed statistically using HSD Tukey test

III. Results

The mean shear bond strength and standard deviation calculated for each group are summarized in the Table 1. The mean shear bond strength value for fifth generation adhesive Tetric N Bond (total-etch) (IVOCLAR) was 13.01, sixth generation adhesive FL Bond II (SHOFU) was 17.48, seventh generation adhesive Tetric N Bond (self-etch) (IVOCLAR) was 15.59, and eighth generation adhesive Tetric N Bond (universal) (IVOCLAR) was 25.11 respectively.

The highest strength was thus seen in eighth generation boding agent followed by sixth generation bonding agent, seventh generation bonding agent and fifth generation bonding agent. Tukey HSD test was performed to determine any statistically significant differences among the groups compared in this study, given in Table 2. There was no statistically significant difference present between fifth and sixth generation, and sixth and seventh generation, and fifth and seventh generation bonding agents. The results are summarized in Graph 1.

IV. Discussion

Primary objective of measuring the bond strength is to assess the bond strength of a bonding agent to the dental hard structures. Advancements in newer dentin bonding agents aim to enhance the bonding quality and shortens the time consumption in application. Factors affecting bond strength are type of tooth, dentin surface, type of bond strength to be tested (shear or tensile), type of bonding agent used, storage media, composite restorative material, and testing procedure.[11]

In the present, in vitro study, four tested dentin bonding agents were fifth generation Tetric N Bond (Total-etch) IVOCLAR, sixth generation FL Bond II, SHOFU, seventh generation Tetric N bond (Self-etch) IVOCLAR & eighth generation Tetric N bond (Universal) IVOCLAR .

In this study, highest mean shear bond strength was observed in eighth generation dentin adhesives (TETRIC N BOND, UNIVERSAL) compared to sixth, seventh and eighth generation adhesives.

According to results of our study eighth generation adhesive was found to be better than fifth generation bonding agent ($P<0.001$). Probable explanation of this result can be that eighth generation adhesives invade through the smear layer, not abolishing it completely, fixing smear plugs at the entrance of the tubules. They contain residual hydroxyapatite in the resin-impregnated smear and hybrid layer which provide additional chemical retention. The result of the present study is in agreement with the result of an earlier study done by Isolan CP et al (2014)[14] who concluded that the bonding ability of the universal adhesive was comparable to the other contemporary bonding agents tested, although it was dependent on the substrate evaluated. Universal adhesives seem to have potential applicability in adhesive dentistry.

This is supported by Susin AH et al (2007)[15] who demonstrated that self etch adhesivees were not affected by the different dentinal substrate conditions (wet, dry and re-wet) producing similar tensile bond strength (TBS) values regardless of surface pretreatments while the total etch produces significantly lower TBS values in different conditions (dry and re-wet).

Leite et al (2005)[16] also concluded that, in order to obtain higher bond strength, the use of self-etching primers is recommended instead of the total etching technique, on air abraded dentin surfaces of primary teeth.

The present results are consistent with the study conducted by Mithiborwala S (2012)[5] who concluded that there is increased thickness of hybrid layer in primary teeth by 25-30%. The density and length of the resin tags were found to be quite adequate in eighth generation adhesives due to the milder acid-etching in these systems. Where as in case of fifth generation adhesives, acids which are too aggressive, expose collagen so deeply that current dentin adhesive resins may not penetrate completely, leaving behind an uninfiltrated weak collagenous layer of dentin susceptible to long-term degradation and low bond strength.

There is no statistically significant difference found between fifth generation and sixth generation bonding agent ($P=0.32$) and fifth and seventh generation bonding agent ($P=0.75$). These results are similar to Afshar H et al (2015)[12] who failed to find statistically significant difference between the fifth and seventh ($P=0.11$) or sixth and seventh ($P=0.2$) generation bonding agents. However, several studies have evaluated the shear bond strength to dentin close to the dentino-enamel junction of primary teeth. Yaseen and Subba Reddy (2009)[17] compared the shear bond strength of sixth and seventh generations adhesives and Senawongse et al (2004)[18] measured the microshear bond strength of fifth generation (Single Bond) and sixth generation (Clearfil SE Bond) adhesives to primary dentin. The results obtained in the aforementioned studies were similar to our study, they failed to find a significant difference between different bonding systems. Poptani et al (2012)[19] after thermocycling didn't find any difference between fifth and seventh generation bonding agent. Stalin A and Varma N (2011)[20] also showed no statistically significant difference between fifth and sixth generations bonding agents and concluded that the self-etching adhesive is better for bonding in primary dentition.

Different components have different constituents. Results of our study revealed that eighth generation adhesive shows better bond strength than seventh generation. This may be due to the component MDP (Methacryloyloxydecyl dihydrogen phosphate) which has potential to bond chemically with hydroxyapatite crystal.[21]

This result was in accordance to the study carried out by Yosheda et al (2004)[21] who concluded that monomer 10-methacryloxydecyl dihydrogen phosphate (10-MDP) readily adhered to hydroxyapatite. This bond appeared very stable, as confirmed by the low dissolution rate of its calcium salt in water.

According to Fukegawa D et al (2006)[22] among functional monomers used in contemporary dental adhesives, 10-methacryloyloxydecyl dihydrogen phosphate (MDP) has been found to interact chemically with

hydroxyapatite most intensively and stably. This effect was thought to be the basis of the superior bonding effectiveness of MDP-based self-etch adhesives to dentin.

Both seventh and eighth generation dentin bonding agents contain functional monomers, cross-linking monomers, solvent, inhibitors, and activators, but in different proportions. Cross-linking monomers provide most of the mechanical strength[23], eighth generation bonding agent contain micro sized cross linking functional monomers therefore, there is a potential for higher bond strength than seventh generation. Joseph et al (2013)[24] and Kamble et al (2015)[11] concluded that eighth generation bonding agent appeared to be more advantageous than sixth and seventh generation bonding agent.

Somani R et al (2016)[25] concluded that the microleakage value was the highest in seventh generation bonding agent followed by sixth generation bonding agent and least in eighth generation bonding agent.

According to results of our study eighth generation bonding agent is showing higher shear bond strength than sixth generation bonding agent. Reduction of a number of application steps should reduce manipulation time, and abate technique sensitivity, thus improving bonding effectiveness. This trend in adhesive dentistry has led to the introduction of eighth generation adhesives, of which the one-step self-etch adhesives or the so-called all-in-one adhesives are the most user-friendly adhesive systems nowadays in the market. Their application procedure involves a single step, combining etching, priming and bonding.[26] Mithiborwala S et al (2011)[27] also stated that reduction in technique sensitivity of any bonding system would always be preferred factor in paediatric restorative dentistry. Thus, inclination towards selection of adhesive system may lean towards the self etching bonding system at this juncture and eighth generation adhesive used in our study is a self etch adhesive.

It is important to consider the composition and the substrate treatment by adhesive factor. Different studies report that the chemical composition of adhesive systems determines clinical success. Polyacrylic acid in fifth generation adhesive and micro sized cross linking agents and MDP monomers in eighth generation adhesive promotes chelation with calcium and the formation of hydrogen bridges with dentin components, it may be the significant factor resulting in higher shear bond strength values in eighth generation and lowest in fifth generation.

V. Conclusion

The greatest mean shear bond strength to dentin of primary teeth was exhibited by eighth generation dentin bonding agent followed by sixth generation, seventh generation and fifth generation dentin bonding agent. So based on results of present study it can be concluded that eighth generation dentin bonding agent has greater advantage in paediatric dentistry. Additionally it also requires fewer steps and is thus less time consuming also.

Clinical significance - There are clear difference shown between bond strength values of different adhesive *systems.* In pediatric dentistry self etch adhesives are not particularly affected by their physical properties but also by the factors related to method required for their application. The current info help at the time of material selection processess in paeditric dentistry.

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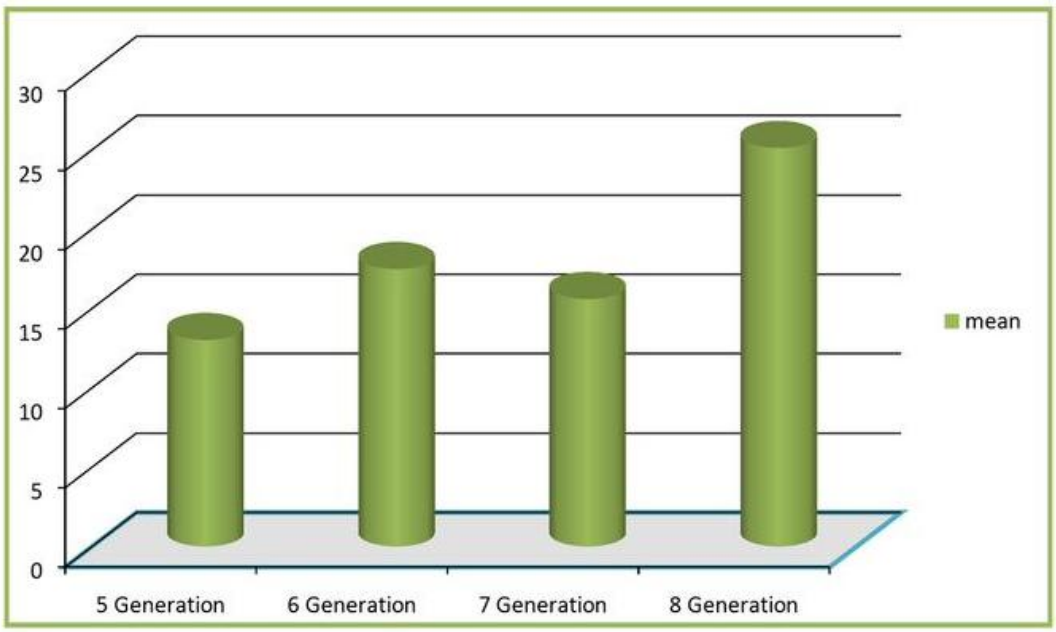
Group	N	Mean shear bond strength	Std. Deviation	Range	
				Minimum	Maximum
5th Generation	15	13.01	7.597	7	33
6th Generation	15	17.48	6.132	8	32
7th Generation	15	15.59	5.519	8	27
8th Generation	15	25.11	8.878	14	48
Total	60	17.80	8.321	7	48

Table No.1 : Shows the mean shear bond strength values of all dentin bonding agents.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Fifth generation (Group 1)	6th Generation	-4.467	2.612	.328
	7th Generation	-2.580	2.612	.757
	8th Generation	-12.100(*)	2.612	.001**
Sixth generation (Group 2)	5th Generation	4.467	2.612	.328
	7th Generation	1.887	2.612	.888
	8th Generation	-7.633(*)	2.612	.025*
Seventh generation (Group 3)	5th Generation	2.580	2.612	.757
	6th Generation	-1.887	2.612	.888
	8th Generation	-9.520(*)	2.612	.003**
Eighth generation (Group 4)	5th Generation	12.100(*)	2.612	.001**
	6th Generation	7.633(*)	2.612	.025*
	7th Generation	9.520(*)	2.612	.003**

Table No. 2: Multiple comparisons by using HSD Tukey test

(*) : significant (**) : highly significant.



Graph No. 1. Comparison of mean shear bond strength of all four groups

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