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Effect of 5.25% Sodium Hypochlorite and 2% Chlorhexidine Digluconate on Shear Bond Strength of one 7th Generation and two 8th Generation Dental adhesives: An in-vitro study

Shakti Singh Meena[1*] B.R. Adyanthaya[2] Atul Bishnoi[3] Abbas Kapasi[4]

[1]Assistant Professor, Department of Conservative Dentistry and Endodontics, Geetanjali Medical and Dental College, Udaipur, Rajasthan, India.
[2]Professor and Head, Department of Conservative Dentistry and Endodontics, Rajasthan Dental College & Hospital, Jaipur, India.
[3]MDS, Department of Conservative Dentistry and Endodontics, Maharaja Ganga Singh Dental College and Research Centre, Rajasthan, India.
[4]Consulting Endodontist at Apollo White Dental Clinic, Whitefield, Bangalore, Karnataka, India.

ABSTRACT

Background: The objective of this study was to evaluate the effect of 5.25% sodium hypochlorite and 2% chlorhexidine digluconate on the shear bond strength of one 7th generation (Adaper Easy One) and two 8th generation (Tetric N-Bond and Futurabond DC) dental adhesives.

Materials and Methodology: One hundred eight freshly extracted human premolar teeth in age group between 20 to 30 years of age were collected. The specimens were randomly divided into three groups of 36 each. Each tooth sample was ground with a diamond bur to remove the enamel layer to obtain a flat occlusal surface. Each group was further divided into two subgroups depending on the type of surface treatment of either 2% chlorhexidine or 5.25% Sodium Hypochlorite solution. Then each sample was cured for 20 seconds and then 2mm thickness of universal restorative composite was placed over the bonded dentinal surface and light cured it for 40 seconds. After 24 hours each specimen was seated on the PVC zig with the help of dental stone. After that shear bond strength was measured using a universal testing machine followed by statstical evaluation of the data obtained.

Results: The obtained results showed that specimen treated with sodium hypochlorite showed better shear bond strength when compared to the specimen treated with chlorhexidine Digluconate. The highest value of bond strength was exhibited by 7th generation adhesive resin Adaper Easy Bond(87.1111 N) treated with sodium hypochlorite and the lowest value was observed with 8th generation adhesive resin Futurbond DC(31.2778 N) treated with chlorhexidine digluconate. Significant difference between the bond strengths of both 8th generation bonding agents (Tetric N-Bond and Futurabond DC) were observed.

Conclusion: The cavity disinfectants such as Sodium hypochlorite and Chlorhexidine Digluconate had significant influence on the shear bond strength of 7th and 8th generation Self-ethch bonding agents.

Keywords: Sodium Hypochlorite, Chlorhexidine Digluconate, Shear Bond Strength.

INTRODUCTION

Restoration of endodontically treated tooth is necessary for clinical success in order to preserve the functional aspect of the tooth, to prevent recontamination, infection and more importantly to prevent recurrent caries.[1] Recent advances in self-etch adhesives are great promise for the clinician because of its simplified steps, clinical time and reduced post operative sensitivity. Restoration of endodontically treated tooth with adhesive system has numerous advantages over conventional non-

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*Correspondence Dr. Shakti Singh Meena.
Department of Conservative Dentistry and Endodontics, Geetanjali Medical and Dental College, Udaipur, Rajasthan, India.
Email: shaktisingh8989@yahoo.com

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adhesive restorative material. With the use of adhesive resin, the functional forces are transferred to the tooth structure by the bonded surface thus reinforcing the undermined remaining tooth structure.[2]

Lack of a proper adhesion and seal between the final restoration and tooth structures in endodontically treated teeth may result in a poor prognosis of the root canal treatment because penetration of microorganisms through the tooth crown once again contaminates the root canal system. Therefore, the quality of the final restoration of the tooth is an important factor for the evaluation of prognosis after root canal treatment.[2] Nevertheless, adhesion to dentin may be affected by many factors. Chemical irrigants used during root canal preparation may alter the chemical composition of dentin surface and affect its interaction with materials used for coronal sealing. The adverse effects of irrigants such as sodium hypochlorite and peroxides on resin-dentin bond strength have been investigated and confirmed previously.[3]

The scientific beginnings of dental adhesion originated in the early 1950's and now bonding agents are used routinely in restorative and preventive dentistry.[4] Forty-five years ago Buonocore reported that adhesion of acrylic resins to enamel could be achieved by etching with 85% phosphoric acid (Buonocore. 1955). Soon afterward adhesion to enamel became a common practice in clinical dentistry. In the mid-1980's clinically significant bond strengths to dentin become possible with the introduction of third generation dentin adhesives such as Scotchbond 2 (3M). The improved dentin adhesion was due to the use of solutions that modified the dentin surface prior to the application of the resin (Burke and McCaughey, 1995). Over the years improvements and modifications to the third generation products resulted in the development of a number of other systems, which were later categorized as fourth and fifth generation adhesives. To this end a number of one-step, or fifth generation dentin bonding agents have been developed which are said to retain the bond strengths of the multiple step systems. At present, these new systems have not been subjected to long-term studies.[5]

Denting bonding agent can be defined as a thin layer of resin applied between the conditioned dentin and resin matrix of composite. Over the years there have numerous classifications of dentin bonding agents that have been advocated by many authorities. Some of the commonly followed classifications include that; based on generations (e.g. First generation dentin bonding agents, second generation dentin bonding agents, third generation dentin bonding agents etc,), a scientific classification based on treatment of smear layer and number of clinical steps; classification based on modern adhesion strategy as total etch or self etch. The total-etch technique, initiated by fusayama advocated etching both enamel and dentin simultaneously using phosphoric acid before the application of a phosphate ester type of bonding agent. Total etch adhesives can be two step adhesives or three step adhesives.[4] The concept of self-etch primers was introduced with Scoth bond 2 in the early 90's. However this system required a selective enamel etching step. The current self etch adhesives provide monomer formulations for simultaneous conditioning and priming of both enamel and dentin.

Nano composites and nano adhesives are one of the greatest contributions of nano dentistry are one of the greatest contributions of nano dentistry which contain nano sized fillers. Nano adhesives are solutions with nano particles which prevent its agglomeration thus producing high dentin and enamel bond strength, high stress absorption, longer shelf life, durable marginal seal and the release of fluorides.[4] Recently dentin adhesives that contain nano fillers have been introduced. The manufactures of one such system of nano filler containing dentin bonding agent (Futurabond DC, Voco, Germany) have claimed them to be the eight generation.[6]

Dental adhesives have dramatically changed the options available for restoration placement since their introduction more than forty years ago. Initially, these required a longer etching time and were only recommended for etching and bonding of the enamel. Dental adhesive developments shortened the etching time and enabled etching and bonding of dentin as well as enamel. However, early generation adhesives had weaker bond strength and allowed marginal leakage at the restoration margin. Today, clinicians have a variety of esthetic

and functional materials to choose from when faced with the need to perform cosmetic dentistry. As dentists, we are always looking for products that are quick and simple to use yet high performing and effective.[7]

Seventh-generation adhesives offer great benefits, whether used as the main adhesive or as an adjunctive bonding agent. The versatility of seventh-generation dental adhesives enables their use for both indirect and direct restorations, providing for excellent marginal seal and high bond strength.[8]

Recently dentin adhesives that contain nano fillers have been introduced. The manufacturers of one such system of nano filler containing dentin bonding agent (Futurabond DC, Voco, Germany) have claimed them to be the eighth generation. Futurabond DC is dual-cured and works with all light-, self- or dual-cured resins. It works in a self-cured mode without any light and takes only 35 seconds from start finish. It has over 30MPa bond strength to dentin and enamel. .[9]

MATERIALS AND METHOD

The present study is in vitro study.

Materials used in this study are:

Adaper ™ easy one

Future DC VOCO

Tetric N-Bond

5.25% Sodium Hypochlorite [DP India]

2% Chlorhexidine Digluconate [Neelkanth India]

Filtek™ Z350 XT Composite syringe [3M USA]

Table 1: Details of the materials used in the study.

Serial no	Materials	Components	Manufacturer
1.	Adaper Easy Bond	• 2-hydroxyethyl-methacryate (HEMA) • Bis-GMA • Methacrylated phosphoric esters • 1,6 hexanediol dimethacrylate • Methacrylate functionalized Polyalkenoic acid • Finely dispersed silica filler with 7 nm primary particle size • Ethanol • Water • Initiators based on camphorquinone • Stabilizers	3M ESPE, USA
2.	Tetric N-Bond Universal	• 2-hydroxyethyl methacrylate (HEMA) • 2 Bis-GMA • Ethanol • 1,10-decandiol dimethacrylate • Methacrylated phosphoric acid ester • camphorquinone • 2-dimethylaminoethyl • Water, • Highly dispersed silicon dioxide • Initiators and Stabilisers	Ivoclar Vivadent, India

3.	Futurabond DC	• Acidic adhesive monomer • BIS-GMA • 2-hydroxyethyl methacrylate • Ethanol • Water • Inititors • Stabilizers	VOCO, Germany

Armamentarium used:

- Airotor Handpiece
- Burs – Straight fissure diamond point (SF-41, Mani)
- Applicator tips
- Visible light curing unit [Coltlex LED]
- Teflon – coated instruments
- Universal testing machine
- Dental stone

Method of collection of Data

One hundred eight freshly extracted human premolar teeth in age group between 20 to 30 years of age were collected from Oral Surgery Department, Rajasthan Dental College and Hospital, Jaipur. Criteria for teeth selection included no signs of crown fracture, no signs of malformed crown, extracted from age group of 20-30 yrs.

Method and Groups:

METHOD:

At first one hundred and eight extracted human premolar teeth in age group between 20 to 30 years of age were collected. They had been extracted at most, two months before the study. One week before the laboratory procedures, the teeth were cleaned of any calculus or soft tissue remnants and stored in distilled water. The specimens were randomly divided into three groups of 36 each.

Each tooth sample was ground with a diamond bur to remove the enamel layer to obtain a flat occlusal surface. Each group was further divided into two subgroups depending on the type of surface treatment of either 2% chlorhexidine or 5.25% Sodium Hypochlorite solution.

GROUPS:

Group A: 36 samples with seventh generation adhesive resin(Adaper Easy Bond) were used.

Sub Group 1: 18 samples, before the application of adhesive resin the specimen were treated with 5.25% NaOCl solution.

Sub Group 2: 18 samples, before the application of adhesive resin the specimen were treated with 2% chlorhexidine digluconate.

Group B: 36 Samples with eight generation adhesive resin(Tetric N-Bond) were used.

Sub Group 1: 18 samples, before the application of adhesive resin the specimen were treated with 5.25% NaOCl solution.

Sub Group 2: 18 samples, before the application of adhesive resin the specimen were treated with 2% chlorhexidine digluconate.

Group C: 36 samples with eight generation adhesive resin(Futurabond DC) were used.

Sub Group 1: 18 samples, before the application of adhesive resin the specimen were treated with 5.25% NaOCl solution.

Sub Group 2: 18 samples, before the application of adhesive resin the specimen were treated with 2% chlorhexidine digluconate

Table 2: Distribution of the study sample in groups and subgroups.

Group	Subgroup	Surface treatment	Bonding agent	Sample size
A	A1	5.25% Sodium Hypochlorite	adapertm easy one (7th generation)	18
	A2	2% Chlorhexidine Digluconate		18
B	B1	5.25% Sodium Hypochlorite	Tetric n bond (8th generation)	18
	B2	2% Chlorhexidine Digluconate		18
C	C1	5.25% Sodium Hypochlorite	Futura dc voco (8th generation	18
	C2	2% Chlorhexidine Digluconate		18

After surface treatment of the each sample as per each group the adhesive resin was applied and dried with 3 way syringe for 5 seconds to each sample depending upon there groups respectively. Then each sample was cured for 20 seconds and then 2mm thickness of universal restorative composite was placed over the bonded dentinal surface and light cured it for 40 seconds. Then the specimens were kept in distilled water for 24 hours at 37 degree. After 24 hours each specimen was seated on the PVC zig with the help of dental stone. After that shear bond strength was measured using a universal testing machine followed by statstical evaluation of the data obtained

RESULTS

Statistical analysis conducted to evaluate and compare the shear bond strengths between the groups of different generations of bonding agents to the different surface disinfection methods, showed significant statistical differences.

The obtained results showed that specimen treated with sodium hypochlorite showed better shear bond strength when compared to the specimen treated with chlorhexidine Digluconate. The highest value of bond strength was exhibited by 7th generation adhesive resin Adaper Easy Bond treated with sodium hypochlorite. In other words the use of sodium hypochlorite significantly increased the bond strength of 7th generation (Adaper Easy Bond) and 8th generation (Tetric N-Bond) bonding agents. Significant difference between the bond strengths of both 8th generation bonding agents (Tetric N-Bond and Futurabond DC) were observed.

Table 3: Comparison of shear bond strength values of sample in all the groups treated by sodium hypochlorite.

	N	Mean	Std. Deviation	Std. Error
Adper	18	87.1111	50.95314	12.00977
Ivachlor	18	77.5000	16.04497	3.78184
Future	18	40.1111	8.79096	2.07205
Total	54	68.2407	36.86330	5.01646

On comparing the bond strengths between the subgroup with surface treatment done with 5.25% sodium hypochlorite, revealed that there was differences in the mean value of all the three subgroups, but the difference was not statistically significant between the group A1 (87.1111 N) and B1 (77.5000 N). However significant statistical difference was observed between the subgroups

comparison of A1 (87.1111 N) to C1 (40.1111 N) and B1 (77.5000 N) to C1 (40.1111 N). The highest value for shear bond strength was presented by subgroup A1 (87.1111 N) and the least value was presented by subgroup C1 (40.1111 N).

The highest value for shear bond strength was observed with subgroup A1 (87.1111 N) while the lowest value was observed with subgroup C2 (31.2778 N). The values of shear bond strength in descending order are as follows:

Group A1 (87.1111 N) > Group B1 (77.5000 N) > Group B2 (54.2778 N) > Group A2 (42.7222 N) > Group C1 (40.1111 N) > Group C2 (31.61053 N)

Comparison of the mean values between the subgroups of group A revealed significant statistical difference between group A1 (87.1111 N) and group A2 (42.7222 N). Similarly, comparison of the mean values between the subgroups of group B revealed significant statistical difference between group B1 (77.5000 N) and B2 (54.2778 N).

On the other hand, there was slight differences of the mean value between the subgroups of group C, however this difference was not statistically significant.

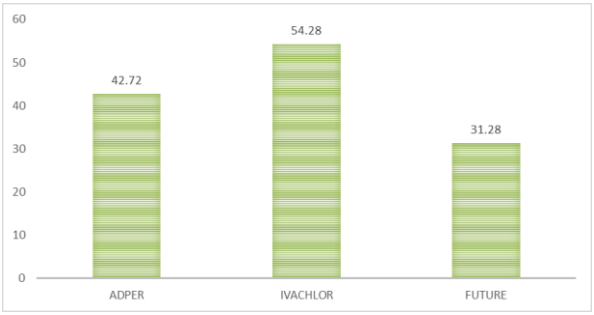
Graph 1: Comparison of shear bond strength of sodium hypochlorite in all groups.

Table 4: Comparision of shear bond strength values of sample in all the groups treated by chlorhexidine digluconate.

	N	Mean	Std. Deviation	Std. Error
Adper	18	42.7222	21.72233	5.12000
Ivachlor	18	54.2778	2.60781	.61467
Future	18	31.2778	3.61053	.85101
Total	54	42.7593	15.73355	2.14107

The evaluation of the comparison of the bond strength between the subgroups of all the three groups where surface treatment was done using 2% chlorhexidine digluconate revealed that there was difference in the mean values of all the three subgroups. Further investigation revealed that there was not much statistical difference when subgroups A2 (42.7222 N) and B2 (54.2778 N) were compared as well as between A2 (42.7222 N) and C2 (31.2778 N). However, there was statistically significant difference between the values of B2 (54.2778 N) and C2 (31.2778). The highest value for shear bond strength was presented by subgroup B2 (54.2778 N) and the least value was presented by subgroup C2 (31.2778 N).

Graph 2: Comparision of shear bond strength of Chlorhexidine in all groups.



DISCUSSION

In current times, development of new products is occurring at an unprecedented rate. In order to understand the current situation with adhesive dentistry, it is important to look to the past and how and why the various generations of adhesives developed. The concept of bonding to enamel and dentin was first considered over 50 years ago by Buonocore. Extrapolating from industrial bonding techniques, he postulated that acids could be used as a surface treatment before the application of resins, and found that etching enamel with phosphoric acid increased the duration of adhesion under water. In 1963 he demonstrated further insight in discussing the differences of bonding to enamel vs. dentin. In the late 1960s, he suggested it was the formation of resin tags in the micro-porosities of etched enamel that were principally responsible for adhesion; with adhesion to dentin proving more elusive due to its composition, water content and the smear layer.[10]

The first dental adhesives therefore only bonded resins to enamel, with little or no adhesion to dentin. Adhesives then evolved step by step with changes in chemistry, application, mechanism, technique and effectiveness – an evolution that accompanied the development of increasingly aesthetic dental materials, notably composite resins and ceramics.[11]

Fusayama et al in 1979, proved that good dentin adhesion can be achieved in vivo by acid etching the dentin before an unfilled resin was placed on the dentin surface. Dentin bonding agents, used during the early 90s, are still in use and are often referred to as a fourth generation of dentin adhesives. Dentist thought that 4th generation of adhesives were complex and time consuming and demanded simpler solutions. The first simplification was the 5th generation of bonding agents, systems in which primer and the adhesive were mixed together and supplied as a simple system. After the development of 5th generation, the demand for simpler systems increased as a result of which two such systems evolved: one consisting of an acid primer and a bonding agent resin referred to as a 6th generation adhesive, and another in which the etchant, primer, and adhesive are combined in a single delivery system marked as seventh generation of adhesive systems.[12]

All-in-one adhesive or 7th generation adhesive contains high amount of solvent (water, acetone or ethanol) and hydrophilic monomer such as 2 hydroxyethyl methacrylate (HEMA), butylated hydroxytoluene (BHT), bisfenol glycidyl methacrylate (bis-GMA). The main difference between total-etch and self-etch adhesive is the liquid acidity. The phosphoric acid used in the total-etching is much more chemically aggressive (pH 0.1-0.6) than the self-etching adhesive (pH 2.5-4.5).[13]

The major difference with 8th generation is that with development in nanotech dentistry has lead to development of nano composites and nano-adhesives which contains nano sized fillers. Nano-bonding agents are solutions with nano fillers which produce better enamel and dentin bond strength, stress absorption, and longer shelf life. It has been observed that filled bonding agents produced higher *in vitro* bond strength.[14]

The main component nano particle that was found in both the Futurabond DC and Tetric N-Bond 8th generation was the highly functionalized SiO_2 particles (20nm). It facilitate a cross-linking of the bonding's resin components and enhance its film building properties. Thus, the adhesive can optimally wet the exposed collagen fibres and micro-retentive etching pattern on the enamel. This optimizes cross-linking density and wetting properties as well as reinforces the adhesive layer.[14]

Dentin adhesives are currently available as three-step, two-step and single-step systems, depending upon how the three cardinal steps of etching, priming and bonding to tooth substrate are accomplished.[15]

One of the problems faced in adhesive dentistry is resin-dentin bond degradation by water and vapor over a period of time. Bonding to enamel remains the simplest and most reliable of all adhesive procedures. Bonding to the dentin is where the clinician faces difficulty mainly due to the contents of the dentin, i.e. 45% inorganic and the rest being organic and water. Lower bond strength to dentin occurs as a result of numerous factors. Dentin contains less mineralized tooth structure and more water than enamel. Outward pressure from the pulp reduces the stability of the bond between the composite resin and dentin. To overcome these problems, dental adhesive systems have evolved through several generations with changes in mechanisms, chemistry, number of bottles, application techniques and clinical effectivesness.[12]

The newer concepts of self-etching primers and adhesives have proven to be good both scientifically and clinically. They reduce the clinical steps, can be placed inexpensively, provide adequate bonding to enamel and dentin and most importantly, ensure postoperative comfort to patients.[15]

Various studies, evaluating shear bond strength of self-etching adhesive have shown inconclusive results on permanent dentition. The advantages of the self-etching system include complete infiltration of the bonding agent into the demineralized dentin and a reduce number of clinical procedural steps.[16]

In our study we have attempted to evaluate the shear bond strength of a 7th generation bonding agent (Adaper Easy One) and two 8th generation

bonding agent (Tetric N-Bond ad Futurabond DC) after the dentine surface disinfection with either Sodium Hypochlorite solution or Chlorhexidine Digluconate. A durable bond between the tooth structure and composite resin is necessary for the clinical success of tooth-colored restorations because bond failure at restoration margins results in the microleakage of oral liquids and penetration of bacteria, leading to recurrent caries. [17]

Conventional removal of carious tissue and cavity preparation procedure do not guarantee the complete elimination of oral cariogenic bacteria that might be entrapped within the dentin tubules or the smear layer, which may induce secondary caries or pulpal inflammation. For these reasons, elimination of the bacteria from the cavity surfaces is of major importance.[18]

Thus it becomes an important factor which could influence the bonding strength between the various commercially available bonding systems available and since single step bonding have shown to be highly influenced by surface treatments and are technique sensitive, these interactions need to be evaluated.[19]

single step bonding have shown to be highly influenced by surface treatments and are technique sensitive, these interactions need to be evaluated.[19]

The most commonly used antimicrobial agent up to now has been NaOCL. Since the smear layer composition is similar to the originating tissue (50 volume % mineral and 30 volume % collagen), the application of (NaOCl) over the smear layer covered dentin would eliminate its collagen phase resulting in reduction in the smear layer compactness. This property enhanced the bonding of the self-etching adhesive as it might increase the diffusively of the acidic monomers, through water-filled channels between particles of smear layer enlarging them to reach and interact with the underlying dentin surface. Depending on the testing methodology and the adhesive system composition, the application of sodium hypochlorite may increase, decrease, or have no effect on bond strengths.[18]

Most studies report the decreased bond strength values after NaOCL treatment. It has been claimed that remnants of superoxide radicals generated by NaOCL within the dentin surface inhibit polymerization of resin monomers. However in the present study, NaOCL improved the bond strength when the self-etching systems were used. This might be related with the adhesive systems composition.[18]

In another study it was reported that the effects of NaOCL pretreatment on bonding of both self-etch adhesives were dependent upon type of dentin and the treatment time. In most of the studies conducted by various researchers, the application time was normally in the range of 20 seconds as per manufacturer recommendation but in my study I have applied it for 40 seconds also the concentration of sodium hypochlorite was 5.25% where as in most of the conducted study the concentration of sodium hypochlorite was around 2%, both this factor could may have led to increased surface treatment and improved bonding.[20]

Chlorhexidine has also been widely used as an antimicrobial agent as well as for disinfection before the placement of restorations. CHX is a bis-bis-guanide that acts by adsorbing onto the cell wall of microoraganisms resulting in leakage of intracellular components. As it has a rewetting capacity and a strong affinity to tooth structure, it might have been expected that CHX would improve dentin bond strengths.[21]

Loss of hybrid layer integrity compromises resin-dentin bond stability. Matrix metalloproteinase (MMP) may be partially responsible for hybrid layer degradation. CHX acts as matrix metalloproteinase (MMP) inhibitor, so it has beneficial effects on the preservation of dentin bond strength. According to a study of Ercan et al the pretreatment of dentin surfaces with NaOCL or CHX solutions had a negative effect on the shear bond strength of self-etch adhesive systems. Celik et al found that CHX effect on bond strength might differ according to the type of the adhesive system used.[18]

In this study evaluation of the surface treatment of prepared dentin surface with Chlorhexidine and Hypochlorite was done, and the results obtained revealed that the overall effects of the two disinfectants when used with single bottle (7th and 8th Generation) bonding system resulted in stronger shear bond strengths with Sodium Hypochlorite solution with a statistically significant difference

when compared to Chlorhexidine Digluconate which resulted in lower shear bond strengths.

When comparison was done based on the denominator of a particular bonding system used, the results obtained from my study revealed that the highest values of shear bonding strength was present with Adper Easy Bond Self-Etch Adhesive (with Sodium Hypochlorite) 87.1111 N which is a 7th generation bonding agent. The possible explanation for this is that unlike the total-etch systems the etching and subsequent penetration of resin monomers into the demineralized dentin and enamel is carried out as one step with Adper™ Easy Bond Self-Etch Adhesive. A major benefit of this procedure for dentin bonding is that the etching depth and the depth of penetration of the adhesive are identical.[22]

Eliminating the need for a separate etching step allows for the simultaneous etching and adhesive penetration. In the case of dentin bonding, this keeps the collagen fibers from collapsing and eliminates dependence on "moist" bonding which is characteristic of the 5th generation "one-bottle" systems. This is important because technique sensitivity associated with bonding systems requiring a "moist" bonding technique may be associated with postoperative sensitivity. A possible adhesion mechanism for the original Prompt™ L-Pop™ adhesive was described by Professor Reinhardt (University of Münster) and can also be used to describe, in part, the mechanism of Adper Easy Bond Self-Etch Adhesive.[23]

Adper Easy Bond Self-Etch Adhesive includes phosphoric esters, which under aqueous conditions will etch the surfaces of dentin and enamel to allow for the micromechanical bonding of a restorative material. Moreover, the phosphoric esters and the Vitrebond™ Copolymer in Adper Easy Bond Self-Etch Adhesive form a chemical bond to the hydroxyapatite by forming a complex with the calcium ions.[23]

Bonding to dentin with Adper Easy Bond Self-Etch Adhesive involves dissolving the inorganic smear layer and the deminerialization of the intertubular dentin. Simultaneously the adhesive penetrates the demineralized dentin to form the hybrid layer and flows into the dentin tubules to create resin tags. The depth of the demineralized zone corresponds to the depth of penetration of the monomers to be polymerized. Nanoleakage, resulting from an insufficient penetration depth of the adhesive can be prevented by this mechanism. [22]

However, this group also showed the highest number of critical failures amongst the samples which can be attributed to the fact that over drying of the surface may have occurred and thus this adhesive system being technique sensitive.[23]

The bond strength of Adper easy bond adhesive was, however, compromised with the surface treatment with Chlorhexidine as surface disinfectant, with bond strength mean value at 42.7222 N. This can be attributed that the presence of bisguanide adsorbed on the surface which may act as interference to bonding.[18]

Tetric N-Bond Universal is a single component, light-cured adhesive for direct and indirect bonding procedures. The formulation of Tetric N-Bond Universal consists of proven ingredients from Tetric N-Bond and Tetric N-Bond Self-Etch as well as of new components from other Ivoclar Vivadent products. It contains methacrylates, ethanol, water, highly dispersed silicon dioxide, initiators and stabilizers. In our study the values obtained for the bonding strength of Tetric N' Bond (with Hypochlorite) was observed to be high at 77.5 N.[10] Similar to Adper Easy Bond adhesive, bonding strength reduced following the treatment of dentin surface with Chlorhexidine surface (54.2778 N). The effective bond strength between Adper and Tetric may be attributed to the reason that Tetric N-Bond Universal and universal adhesives in general, contain low levels of acidic monomer, and are therefore "mild-etching" adhesives.[24]

Tetric N-Bond Universal has a pH of approximately 2.5 – 3.0. The Tetric N-Bond Universal matrix is based on a combination of monomers of hydrophilic (hydroxyethyl methacrylate/HEMA), hydrophobic (decandiol dimethacrylate/D3MA) and intermediate (bis-GMA) nature. This combination of properties allows Tetric N-Bond Universal to reliably bridge the gap between the hydrophilic tooth substrate and the hydrophobic resin restorative, under a variety of surface conditions.[10]

Futurabond DC is a dual-cured, self-etching bonding agent that is reinforced with nano-particles.

Futurabond DC is available in SingleDose blister packs or in 4-ml bottles. The SingleDose blister is easy to activate and mix with the applicator brush included, but there is no way to determine visually if the product is adequately mixed. Futurabond DC consistently earned high ratings for its viscosity and wettability. Editors reported that it was easy to wet the tooth surface with the material and it was easy to apply. The entire bonding process is time-efficient.[25]

But in our findings, we found that the least values for shear bond strength was observed with futurabond dc with both the subgroups sodium hypochlorite (40.111 N) and chlorhexidine (31.2778 N). Futura-bond DC contains polyfunctional adhesive monomers (phosphoric acid modified methacrylate esters). These acid esters, when mixed with water, produced a pH value of 1.4. Accordingly, the smear layer was mobilized and the hydroxyl apatite was dissolved (demineralized), creating a retentive pattern on the enamel surface.[26]

In this study, during the etching process, the acids in the bonding agent were neutralized by hydroxyapatite in the tooth structure; that is, this process only runs until the acid is exhausted. Once the surface has been conditioned, the surface area was increased and bonding resin was penetrated into the etched pattern analogous to conventional etching with phosphoric acid, producing a retentive adhesion. Chemical bonding also takes place in the surface of the tooth structure due to complexation of the calcium by the adhesive thus it can be suspected that limited etching depth and penetration is observed with Futurabond DC which is due to its self-limiting chemical reaction.[13]

Mild self-etching partially removes the smear layer forming a thin hybrid layer. It has the great advantage of leaving substantial amount of hydroxyapatite crystals around the collagen fibrils which may establish chemical bond with specific carboxyilic and phosphate group of function monomers. Adaper Easy Bond and Tetric N-Bond both are mild self-etchants and thus this could be the reason why they show better shear bond strength than Futurabond DC. [27]

In the current study, only adhesives which used wet bonding were used. This eliminated the risk of incompatibility between any of the adhesives and a single resin composite. However, there is not much evidence to indicate that different bonding agents with different pH result in different bond strength outcomes. These should be taken into consideration during interpretation of the outcome of the current study. Further *in vitro studies* are needed to correlate with findings of the present study.

CONCLUSION

Within the limitations of the current study, it can be concluded that cavity disinfectants such as Sodium hypochlorite and Chlorhexidine Digluconate had significant influence on the shear bond strength of 7th and 8th generation Self-ethch bonding agents.

In the present study 5.25% sodium hypochlorite and 2% Chlorhexidine Digluconate were used for 40 seconds over the prepared tooth surface before the application of 7th and 8th generation bonding agents. The obtained results showed that specimen treated with Sodium hypochlorite showed better shear bond strength when compared to the specimen treated with Chlorhexidine Digluconate. In other words the use of Sodium hypochlorite significantly increased the bond strength of 7th generation (Adaper Easy Bond) and 8th generation (Tetric N-Bond) bonding agents. However, significant differences between the bond strengths of both 8th generation bonding agents (Tetric N-Bond and Futurabond DC) were observed. The highest value for shear bond strength was observed with Adper Easy Bond + 5.25% Sodium hypochlorite (87.1111 N) while the lowest value was observed with FuturaBond DC + Chlorhexidine Digluconate (31.2778 N). Additionally, further studies need to be conducted to analyze the effects of different concentrations of Sodium hypochlorite and Chlorhexidine Digluconate solutions, the association of these solutions to self-etching adhesive systems and their influence on application on bonding stability over time.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

REFERENCES

1. Vongphan N, Senawongse P, Somsiri W, Harnirattisai C. Effects of sodium ascorbate on

microtensile bond strength of total-etching adhesive system to NaOCl treated dentine. Journal of dentistry. 2005 Sep 30;33(8):689-95.

2. Chaharom ME, Kahnamoii MA, Kimyai S, Moghaddam MH. Effect of sodium hypochlorite on the shear bond strength of fifth-and seventh-generation adhesives to coronal dentin. African Journal of Biotechnology. 2011 Oct 3;10(59):12697.

3. Santos JN, de Oliveira Carrilho MR, De Goes MF, Zaia AA, de Almeida Gomes BP, de Souza-Filho FJ, Ferraz CC. Effect of chemical irrigants on the bond strength of a self-etching adhesive to pulp chamber dentin. Journal of Endodontics. 2006 Nov 30;32(11):1088-90.

4. Joseph P, Yadav C, Satheesh K, Rahna R. Comparative evaluation of the bonding efficacy of sixth, seventh and eight generation bonding agents: An in vitro study. Int Res J Pharm. 2013;4(9):143-7.

5. De Sousa Vieira R, Da Silva IA. Bond strength to primary tooth dentin following disinfection with a chlorhexidine solution: an in vitro study. Pediatr Dent. 2003;25(1):49-52.

6. Abdalla AI, Davidson CL. Shear bond strength and microleakage of new dentin bonding systems. American journal of dentistry. 1993 Dec;6(6):295-8.

7. A. C. M. Villela-Rosa, M. Gonc¸alves, I. A. Orsi, and P. K. Miani, "Shear bond strength of self-etch and total-etch bonding systems at different dentin depths," BrazilianOral Research, vol. 25, no. 2, pp. 109–115, 2011.

8. Pashley DH, Tay FR.Aggressiveness of contemporary 21 J Dent Res Updates 2014 Dec;1(1):18-22 DBA- update self-etching adhesives. Part II: Etching effects on un-ground enamel. Dent Mater 2001;17:430- 444.

9. Eun-Mi S, Hyeon-Cheol K, Bock H and Jeong-KP. The effect of different bonding systems on shear bond strength of repaired composite resin. Journal of Korean academy of conservative dentistry. 2008 Mar;33(2):125-132.

10. Tetric N-Bond Universal: Scientific Documentation.

11. Jahromli MZ, Mirzakouchaki Boroujeni P, Moshreffar A, Zamiran S. Effect of Chlorhexidine 2% on the Shear Bond Strength of Different Composite Resins to Dentin. International Journal of Current Research and Academic Review.2015 April; 3(4):367-372.

12. Shah DD, Chandak M, Manwar N, Mani S, Mani A, Saini R, Malde R. Comparing Shear Bond Strength of Two Step vs One Step B onding Agents on Ground Enamel and Dentin: An in vitro Study. International Journal of Experimental Dental Science. 2014 Jan 8;3(1):1-3.

13. Abdalla AI, Feilzer AJ. Two-year water degradation of self-etching adhesives bonded to bur ground enamel. Operative dentistry. 2009 Nov;34(6):732-40.

14. Paul J, Yadav C, Kumar S, Rahna R. Comparative evaluation of the bonding efficacy of sixth, seventh and eighth generation bonding agents: An in vitro study. Int Res J Pharm 2013;4:143-147.

15. Kakar S, Goswami M, Nagar R. Dentin bonding agents-II recent trials. World J Dent. 2012 Jan; 3:1158.

16. Sabatini C, Wu Z. Effect of Desensitizing Agents on the Bond Strength of Mild and Strong Self-etching Adhesives. Operative dentistry. 2015 Sep;40(5):548-57.

17. Garcia RN, Giannini M, Takagaki T, Sato T, Matsui N, Nikaido T, Tagami J. Effect of dentin desensitizers on resin cement bond strengths. South Brazilian Dentistry Journal. 2015 May 29;1(12):14-22.

18. Arslan S, Yazici AR, Gorucu J, Ertan A, Pala K, Antonson YU, Antonson DE. Effects of Different Cavity Disinfectants on Shear BondStrength of a Silorane-based Resin Composite. The journal of contemporary dental practice. 2011 Jul 25;12(4):279-86.

19. Atefat M, Sadeghi M. Comparison of Shear Bond Strength of Three Generations of Resin Bonding Agents and Glass Ionomer to Dentin. Journal of Islamic Dental Association of IRAN (JIDAI). 2015;27(1):1.

20.Cavalcanti AN, Souza ES, Lopes GD, Freitas AP, Araújo RP, Mathias P. Effect of a desensitizing dentifrice on the bond strength of different adhesive

systems. Brazilian Journal of Oral Sciences. 2013 Jun;12(2):148-52.

21. Farghal NS, Abdalla AI, El-Shabrawy SM, Showaib EA. The effect of combined application of new dentin desensitizing agent and deproteinization on dentin permeability of different adhesive systems. Tanta Dental Journal. 2013 Dec 31;10(3):138-44.

22. Adper Easy Bond self-etch adhesive: Adaper technical product file brochure.

23. Technical Product Profile. Adper Prompt L-Pop and Adper Prompt. Special Report 3 M Espe. 2004; 1–21.

24. Tetric N-Bond Universal Ivoclor vivadent. Safety Data Sheet

25. Futurabond DC product brochure.

26. Futurabond DC VOCO. Safety Data Sheet

27. Susin AH, Vasconcellos WA, Saad JR, Oliveira Junior OB. Tensile bond strength of self-etching versus total-etching adhesive systems under different dentinal substrate conditions. Braz Oral Res 2007;21(1):81-6.