THE EFFECT OF A DENTIN DESENSITIZER ON THE SHEAR BOND STRENGTH OF COMPOSITE TO DENTIN USING THREE DIFFERENT BONDING AGENTS: AN *IN VITRO* STUDY

Study submitted to

The Tamil Nadu Dr M.G.R. Medical University

In partial fulfillment of the degree of

MASTER OF DENTAL SURGERY

BRANCH IV

CONSERVATIVE DENTISTRY

AND ENDODONTICS

2013 - 2016

<u>CERTIFICATE</u>

This is to certify that this study titled ***"The effect of a dentin desensitizer on the shear bond strength of composite to dentin using three different bonding agents: An in vitro study"*** *is a bonafide record of the work done by Dr. Eeshan Mushtaq under our guidance during her post graduate study during the period of 2013-2016 under* **THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY, CHENNAI,** *in partial fulfillment for the degree of* **MASTER OF DENTAL SURGERY IN CONSERVATIVE DENTISTRY & ENDODONTICS, BRANCH IV.** *It has not been submitted (partial or full) for the award of any other degree or diploma.*

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This is to certify that the research project protocol, ***Ref no. 06/08/2014***titled, ***"The effect of a dentin desensitizer on the shear bond strength of composite to dentin using three different bonding agents: an in vitro study"***submitted by ***Dr.EeshanMushtaq, IIYear MDS, Department of Conservative Dentistry and Endodontics***has been approved by the Institutional Research Committee at its meeting held on 12*th* ***August 2014.***

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Ref. No. SMIMS/IHEC/2015/A/03 **Date: 10th April 2015**

Certificate

This is to certify that the Research Protocol Ref. No. **SMIMS/IHEC/2015/A/03**, entitled "Effect of Dentine Desensitizer on The Shear Bond Strength of Composite to Dentin Using Three Different Bonding Agents: An *In Vitro* Study" submitted by Dr. Eeshan Mushtaq, Postgraduate of Department of Conservative Dentistry and Endodontics, SMIDS has been approved by the Institutional Human Ethics Committee at its meeting held on 13th of March 2015.

[This Institutional Human Ethics Committee is organized and operates according to the requirements of ICH-GCP/GLP guidelines and requirements of the Amended Schedule-Y of Drugs and Cosmetics Act, 1940 and Rules 1945 of Government of India.]

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CONTENTS

LIST OF ABBREVIATIONS

HEMA-Hydroxyethyl methacrylate	SPSS - Statistical Package for Social Sciences
DC- Dual cure	4-META - 4-methacryloxyethyl trimellitate
MPa- Megapascals	NTG-GMA -N-phenylglycine and glycidyl methacrylate
N - Newtons	Eg- Example
sec- Seconds	µTBS-Micro-tensile bond strengths
SE – Self etch	FNR - Futurabond Nano reinforced
TEM- Transmission electron microscopy	UDMA- Urethane dimethacrylate
PENTA - Pentaerythritolpentacrylate phosphorous acid ester	NT - Nanotechnology
BPDM- Biphenyl dimethacrylate	i.e. – that is
FTIR- Fourier transform Raman and infrared spectroscopy	SBS – Shear Bond strength
µm –Micrometer	TBS-Tensile bond strength
SEM -Scanning Electron Microscopy	Etc. – etcetera
ANOVA - Analysis of Variance	Fig.- Figure

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ABSTRACT

Introduction

Pain is one of the most frequent reasons for seeking dental treatment and clinical observations confirm that patients complain of dentinal sensitivity under different conditions and degrees of intensity. This is a very frequent problem after dental restorations with resin composite, even when there is no visible failure in the restoration. There are various causes of postoperative sensitivity in direct resin composite restorations related to failures in diagnosis and indications for treatment and/or cavity preparation, the stages of hybridization of hard dental tissues, insertion of the material, and finishing and polishing the restoration. To avoid or minimize the occurrence of postoperative sensitivity, it is imperative to make a good diagnosis and use the correct technique at all stages of the restorative procedure.

There are various methods to reduce and minimize postoperative sensitivity followed by a composite resin restoration which include reducing dentin permeability or fluid flow by occluding dentinal tubules with potassium oxalate, sodium fluoride, adhesives, desensitizers or by prevention of repolarization of nerves with potassium nitrate.

With the advancements in adhesive dentistry, simplified techniques and improved clinical developments are increasingly being sought. In current times, development of new products is occurring at an unprecedented rate. Dentin adhesives are currently available as three-step, two- step, and single-step systems, depending on how the three cardinal steps of etching, priming and bonding to tooth substrate are accomplished. The newer concepts of self etching primers and adhesives are proving to be good both scientifically and clinically. They reduce the clinical steps, provide adequate bonding to enamel and dentin but as far as bond strength values are concerned, there is still scope for enhancement when compared with total etch adhesives.

However, a concern may arise whether addition of a dentine desensitizer prior to bonding will affect the shear bond strength values.

Aims and Objectives

The aim of this study was to assess the effect of dentin desensitizer Systemp on shear bond strength of composite resin to dentin and to evaluate the shear bond strength with and without the use of dentin desensitizer Systemp using adhesives Prime and Bond NT, Xeno V^+ and Futurabond DC.

Methodology

Sixty recently extracted human maxillary premolars were used for the study and stored in distilled water .The roots were sectioned off with a diamond disc and the occlusal surface of the crowns were sectioned to expose the superficial dentin surface. Each tooth was then embedded into a rectangular metal mould using self- cure resin such that the exposed occlusal dentin surface faced upwards. The specimens were randomly divided into six groups of ten specimens each. In all the groups the flattened dentin surface was etched with 37% phosphoric acid gel. In Group I, Group II and Group III , two coats of Prime and Bond NT , XenoV^+ and Futurabond DC bonding agent was applied on dentin respectively. The samples were light cured according to the manufacturer's instructions. In Groups IV, V and VI, Systemp desensitizer was applied to dentin for 10s with the help of an applicator brush and was allowed to remain on the tooth surface for 20 s. Then the area was lightly dried with an air

syringe .Prime and Bond NT, Xeno V^+, Futurabond DC was then applied to dentin of Groups IV, V, VI respectively. Following the application of bonding agent/ Systemp desensitizer Filtek Z350 XT composite resin was condensed into the mould using stainless steel bands which were placed on the exposed dentine surface and light cured for 40 s. The stainless steel bands were removed. The test specimens were subjected to shear bond strength testing using the Instron universal testing machine. The shear bond strength (MPa) was calculated by the ratio of the maximum load (Newtons) to the cross-sectional area of the bonded interface (mm^2). Statistical analysis was done using computer software SPSS (16.0) version. The data was expressed in its mean and standard deviation.

Results and Observations

The analysis of results shows that the mean shear bond strength of Prime and Bond NT increased after application of a dentine desensitizer from 15.07±0.31 to 16.28±2.63 MPa. The mean shear bond strength of Xeno V^+ decreased after application of dentin desensitizer from 14.47±1.31 to 12.31±1.131 MPa. The mean shear bond strength of Futurabond DC decreased after application of dentin desensitizer from 15.47±2.43 to 15.15±0.79 MPa.

Conclusion

In the present study it is well demonstrated that application of dentin desensitizer increased the bond strength of Prime and Bond NT while the bond strength of Xeno V^+ and Futurabond DC reduced after application of a dentin desensitizer.

Clinical significance

Resin based dental composite fillings has increased significantly and it is now a well-established dental procedure. However, polymerization shrinkage and postoperative sensitivity remain a challenge to practitioners. Clinical studies indicate that up to 30% of the study population report postoperative sensitivity following application of posterior composite resin restorations. Desensitizing agents that occludes dentinal tubules to some extent can significantly reduce fluid filtration across dentin and consequently lower the pain response by formation of firm plugs of protein that seal the tubules. These plugs considerably reduce permeability and the incidence of dentinal sensitivity. Hence, the use of a dentin desensitizer before application of bonding agent and restoration with composite may reduce the postoperative sensitivity that occurs with composite restorations.

INTRODUCTION

The use of resin-based composite materials for posterior restorations has continued to gain immense popularity among clinicians and the demand for such aesthetic restorations is increasing. Indeed, resin composite is the most common aesthetic alternative to dental amalgam.[1] Predictable, strong and durable bonds between restorative materials and tooth structures are essential to achieve acceptable mechanical as well as biologic and esthetic properties which has paved way for various breakthrough developments in the field of adhesive restorative dentistry.[2]

With the emergence of improved adhesives and composite resin systems, resin bonded composite treatment has become predictably successful. However, polymerization shrinkage and postoperative sensitivity still remain a tough challenge for clinicians to deal with.[3]Several clinical studies indicate that up to 30% of the study population report postoperative sensitivity following composite resin restorations for posterior teeth.[4]

The postoperative sensitivity followed by a composite restoration could be due to trauma from preparation, leakage of the restoration, with the resultant ingress of bacteria from polymerization shrinkage, deformation of the restoration under occlusal stress, which in turn transmits hydraulic pressure to the odontoblastic processes.[5,6] The hydrodynamic theory proposed by Brannstorm explains that dentinal hypersensitivity is attributable to chemical, thermal, or osmotic stimuli that cause the fluid within the tubules to flow inward or outward. The inward or outward movement of the fluid creates a mechanical disturbance which can excite nerve fibers in the pulp and elicit a pain response.[7]

Many methods have been suggested to reduce the symptoms of dentin hypersensitivity. Modern treatments for hypersensitive teeth are aimed at either reducing tubular fluid movements by reducing permeability of dentin or to reduce the excitability of intradental nerves with neurally active agents .[8] In order to prevent or at least decrease hypersensitivity and to reduce dentin permeability, desensitizing agents are employed to occlude or seal the dentinal tubules. These desensitizing agents can significantly reduce fluid infiltration across dentin. Current desensitizers include components such as fluoride, triclosan, benzalkonium chloride, ethylene diaminetetraacetic acid and Glutaraldehyde.[9]

Systemp is a desensitizer containing Glutaraldehyde and hydroxyethyl methacrylate (HEMA) which can reduce hypersensitivity by sealing or occluding the exposed dentinal tubules by precipitating plasma proteins in the dentinal fluid. [10]

Dental adhesive systems have evolved through several generations with changes in their chemistry, mechanism, number of steps, application techniques, and clinical effectiveness.[11] The total etch technique initiated by Fusayama, advocated etching both enamel and dentin simultaneously using phosphoric acid and application of a primer before the application of a phosphate ester type of bonding agent.[12] Prime & Bond NT is a total etch bonding agent and is the standard for efficiency and bond strength among total etch adhesives. It belongs to the fifth generation of bonding agents. It is an acetone based adhesive which requires a moist dentin surface to produce adequate bonding.[13]

One-Step self-etching adhesives are becoming increasingly more popular due to their easy and fast application procedure. Reduction of different steps in application procedure also entails fewer errors during application of the adhesive. This is often referred to as the “low technique sensitivity” of one-step self-etching adhesives. Self-etch adhesives are very attractive for routine use in a busy daily practice.[12] Compared with etch-and-rinse adhesives, several advantages have been ascribed to self-etching adhesives. Firstly, self-etching adhesives involve a less technique-sensitive procedure, since the etch-and-rinse phase is omitted, maybe which cause collapse of vulnerable demineralized collagen network after acid etching.[14] Secondly, the simultaneous demineralization and resin infiltration ought to lead to an optimally infiltrated hybrid layer.[15] However, recent observations of nanoleakage beyond hybrid layer have shed some doubt on complete resin infiltration. Thirdly, mild self-etching adhesives are assumed to cause less post-operative pain, as they use smear layer as a bonding substrate, leaving residual smear plugs that cause less dentinal fluid flow than etch-and-rinse adhesives.[16]

Xeno V^+ is a one component self-etching dental adhesive designed to bond resin-based light-curing direct restorative materials to enamel and dentin. It provides monomer formulations for simultaneous conditioning and priming of both enamel and dentin with improved bond strength.[17]

Futurabond DC is a dual-cured, self-etching bonding agent that is reinforced with nano-particles and the manufacturers claim that it belongs to the eighth generation of bonding agents.[11]

In light of these developments, the present *in vitro* study was undertaken to evaluate and compare the bonding efficacy of these newer simplified bonding systems when used with and without a dentin desensitizer.

The study hypothesis was that the shear bond strength of composite to dentine would increase after application of a dentin desensitizer.

AIMS & OBJECTIVES

AIM

1. To evaluate and compare the effect of dentin desensitizer Systemp on the shear bond strength of composite resin to dentin using three different bonding agents- Prime and Bond NT, Xeno V^+, Futurabond DC.

OBJECTIVES

1. To assess the influence of dentin desensitizer Systemp on shear bond strength of composite resin to dentin.

2. To compare the shear bond strength values of Prime and Bond NT, Xeno V^+, Futurabond DC with and without the use of dentin desensitizer Systemp.

REVIEW OF LITERATURE

Branstrom *et al*. 1966 [18] in a review article explained dentin hypersensitivity and defined it as a short, sharp pain arising from exposed dentin in response to stimuli, typically thermal, evaporative, tactile, osmotic, or chemical, which cannot be ascribed to any other form of dental pathology. The classic hydrodynamic theory proposed that fluid movement in the tubules cause increased nerve excitability thus eliciting dentinal sensitivity.

Felton *et al.*1991[19] in an *in vitro* study evaluated the desensitizing effect of gluma dentin bond on teeth prepared for complete coverage restorations and reported that gluma primer was profoundly effective as a desensitizing agent on teeth prepared for full crowns. The desensitizing effect was attributed to the presence of Glutaraldehyde in the gluma dentin bond.

Kerns *et al.*1991[20] in an *in vitro* study evaluated the occlusion of dentinal tubules by various clinical procedures including scaling and root planing and application of potassium oxalate.It was concluded that the creation of a smear layer or application of oxalates to occlude dentinal tubules to reduce sensitivity are relatively short-lived. These procedures may provide patient comfort prior to natural occlusion of the tubules.

Reinhardt *et al.*1995[21] performed a study to determine whether the use of Gluma primer as a desensitizing agent affected shear bond strengths of a composite resin and reported that the application of the desensitizing agent had no deleterious effects on the bond strength. The effect may be attributed to the role of Glutaraldehyde as an affective flocculating agent that stabilizes collagen and enhances resin bond with dentin.

Maciel *et al.*1996[22] in a study investigated the effects of acetone, ethanol, HEMA, and air on the stiffness of human decalcified dentin matrix and concluded that the stiffness of decalcified human dentin matrix is low when the specimens are wet with water and as they are dehydrated, either chemically in water miscible organic solvents or physically in air, the stiffness increases. The increase in modulus was rapidly reversed by rehydration in water. Exposure to Glutaraldehyde also produced an increase in stiffness that was not reversible when the specimens were placed back in water.

Tay *et al.*1996[23] in a study described the micromorphologic spectrum of the resin-dentin interface after application of two dental adhesives to acid-etched dentin under diverse dry and wet conditions. The adhesives used were water free, acetone-based, single-bottle adhesives One-Step and Prime & Bond. The results of the transmission electron microscopic analysis showed that the optimal substrate condition for bonding depended upon keeping the demineralized collagen network moist, coupled with the complete evaporation of excess and displaced water from the substrate prior to adhesive polymerization. Both adhesives showed comparable results.

Jain *et al.*1997[24] in an *in vitro* study examined dentin desensitizing agents by SEM and X-ray microanalysis assessment.The desensitizing agents evaluated were Sensodyne dentin desensitizer (solution of ferric oxalate), Therma-Trol Desensitizer Gel (solution of potassium oxalate), Gluma Desensitizer (Glutaraldehyde, HEMA, and water) and All-Bond DS (resin primers containing NTG-GMA and BPDM).The results showed that all materials produced excellent tubular occlusion upon initial application however no change was observed in tubular occlusion with Gluma

Desensitizer.This may be explained by the fact that the mechanism of action is thought to be different from the others. Instead of relying on superficial occlusion of the tubule orifice, Gluma Desensitizer has been shown to coagulate plasma proteins in the dentinal fluids, thus forming a "coagulation plug" within the tubules.

Schupbach *et al.*1997[25] in an *in vitro* study evaluated the closing of dentinal tubules by Gluma desensitizer using various microscopic techniques and reported that Glutaraldehyde which is a component of Gluma desensitiser can intrinsically block dentinal tubules and the septa in the tubules may counteract the hydrodynamic mechanism for dentinal sensitivity. SEM and TEM evaluation confirmed tubular occlusions to a depth of 200 micrometer in treated samples.

Perdigao *et al.*1998[26] in an *in vitro* study investigated the effect of a re-wetting agent on the performance of acetone-based dentin adhesives and concluded that the application of a rewetting agent (35% HEMA in water) on etched and dried dentin surfaces maintains or improves the bond strengths of two acetone based adhesives to levels comparable to those obtained with the application of the adhesives on moist dentin.

Perdigao *et al.*1998[27] in an *in vitro* study evaluated the effect of a re-wetting agent on dentin bonding and the results of the bond strength tests and the morphologic analysis of the bonded interfaces suggest that the use of an aqueous solution of 35% HEMA is effective as a re-wetting agent when dentin is dried after etching and rinsing.

Cardoso *et al.*1998[28] described microtensile bond strength testing. It has a number of potential advantages: higher interfacial bond strengths can be measured, possible to determine regional bond strengths, it permits testing of bonds to irregular surfaces and very small areas, means and variances can be calculated for single teeth, yields more adhesive than cohesive failures.

Gillam *et al.*1999[29] conducted a study using scanning electron microscope to investigate whether selected in office desensitizing agents occluded dentine tubules in the dentin disc model. Both surface effects and tubules penetration of the five selected test products were scanned, the result demonstrated that all applied desensitizing agents produced some occlusion of the tubules although the level of coverage and occlusion varied between products. Of these agents ferric oxalate produced crystal like structure which occluded a higher portion of the tubules across the dentine disc surface. Both quantitative and functional studies are required in order to determine the effects of these agents and dentin permeability. Even clinical studies are required to determine their effectiveness in reducing pain arising from dentine sensitivity.

Ritter *et al.*2000[30] in an *in vitro* study evaluated the effects of different re-wetting techniques on dentin shear bond strengths. Dentin was etched, rinsed, and eitherblot-dried, air-dried, or air-dried and re-wetted with distilled water, Gluma desensitizer **(35%** HEMA +5% Glutaraldehyde) aqua-prep (35% HEMA), and 5% Glutaraldehyde in water. The two adhesives used in the study were single bond (ethanol and water-based) and Prime & Bond NT, (acetone-based) which were applied to each of the surface conditions and assessed by shear bond strength analysis. The results showed that HEMA- and Glutaraldehyde based solutions can be successfully used as re wetting agents. A solution containing Glutaraldehyde or HEMA might be more beneficial than water as a re-wetting agent when dentin is dried after acid etching and rinsing.

Jacobson *et al.*2001[31] in an article described the two principal treatment mechanisms for dentinal hypersensitivity. He advocated plugging of the dentinal tubules and preventing the fluid flow. Eg: iontophoresis, dentine bonding agents etc.Another modality for treatment could be to desensitize the nerve making it less responsive to stimulation. Eg potassium nitrate.

Soena *et al.*2001[32] investigated the influence of three dentin hypersensitivity agents on the bond strength of two luting agents to dentin. Sixty dentin substrates were divided into 12 combinations of four treatments conditions and three adhesive systems. After bonding the treated teeth were attached to steel rods to measure tensile bond strength. The results showed statistical significant lower bond strength in teeth treated with MS coated desensitizer in Panavia Fluoro cements and statistical significant higher bond strength in Saforide treated group in AD Gel bplus Panavia Flouro cements groups.

Bouillaguet *et al.*2001[33] in an *in vitro* study compared the dentin bonding performance of eight adhesive systems using a microtensile bond strength test and concluded that the conventional adhesive systems produced higher bond strengths to root dentin than most one-step adhesives and one self-etching adhesive; with the exception of one material in each respective system.

Perdigao *et al.*2002[34] in an *in vitro* study evaluated the microtensile bond strengths of three dentin adhesives applied on clinically moist dentin or on dentin that was dried with air for *5* seconds and concluded that the level of residual moisture did not influence microtensile bond strengths. The study also confirmed that clinically, the degree of moisture left on the dentin surface upon rinsing off the etching gel may not be as relevant as previously reported in laboratory studies.

Kolker *et al.*2002[35] in an *in vitro* study evaluated effect of five dentin desensitizers; Gluma desensitizer, Seal &Protect, Hurriseal, D/Sense & Super seal on permeability and morphological changes in dentin tubule that concluded significant reduction in permeability and varying degree of dentinal tubule occlusion .Super seal was found to be most beneficial in treating dentin sensitivity.

Seara *et al.*2002[36] in an *in vitro* study evaluated the influence of a dentin desensitizer on the micro tensile bond strength of two bonding system and concluded that D/Sense 2 desensitizer decreased the micro tensile bond strength of Prime & Bond 2.1 and Bislite II SC bonding system.

Tay and Pashley.2003[37] in a review article discussed current trends in the development of dentin adhesives and the possibility that some classes of currently available adhesives are too hydrophilic. It is observed that manufacturers have reformulated dentin adhesives to make them more compatible for bonding to intrinsically moist, acid-etched dentin by adding 2-hydroxyethyl methacrylate and other hydrophilic resin monomers. These 3-step adhesives work well but are more time consuming to use and more sensitive to technique than the newer, simplified adhesives. The most recent single-step self etching adhesives are even more hydrophilic and hence more permeable to water derived from the underlying bonded dentin. This permeability can lead to a wide variety of seemingly unrelated problems, including incompatibility of chemically or dual-cured composites with simplified adhesives and expedited degradation of resin–dentin bonds.

Qahtani *et al.*2003[38] in a study evaluated rewetting of dry dentin with two desensitizers They concluded that Hurriseal desensitizer is effective as a dentin rewetting agent and can render the bonding procedure less technique sensitive;

however Protect desensitizer reduced the shear bond strength of dentin bonding agents to the dentin surfaces.

Calneto *et al*.2004[39] in an *in vitro* study compared the effect of a self-etching primer and a non-rinse conditioner with the effect of a conventional adhesive system on the penetration depth in dentin of human teeth, using scanning electronic microscopy (SEM). The author concluded that the self-etching primer and the non-rinse conditioner provide a lower penetration depth in human tooth dentin than the conventional adhesive system.

Ernst 2004[40] in a overview on self-etching adhesives emphasizes that Self-etching adhesives are an excellent supplement to existing conventional adhesives and that clinically studies have proven that self-etching adhesives work sufficiently well in Class I and V and restorations .In pediatric dentistry too self-etching adhesives allow for a smoother treatment session because the rinsing and suctioning are not needed with the added advantage of improved bonding to primary enamel.

Huang *et al.*2004[41] in a study evaluated the effect of thermocycling and dentine pre-treatment on the durability of the bond between composite resin and dentine and concluded that the pre-treatment and thermocycling of the dentine had a significant effect on the shear bond strength between composite resin and dentine. In comparison with the conventional acid-etching treatment, the dentine surface created after laser irradiation and the self-etching system had a smaller degradation rate in shear bond strength over a period of thermocycling in artificial saliva.

Luhrs *et al.*2004[42] in a study evaluated the shear bond strength of self etch adhesives to enamel and the effect of additional phosphoric acid etching increased the shear bond strength of all the examined self etch adhesives . The highest shear bond strength was found for FNR after phosphoric acid etching. Without phosphoric acid etching, only FNR showed no significant differences compared to the control . SEM evaluations showed mostly adhesive fractures. For all the self-etch adhesives, a slight increase in mixed fractures occurred after conditioning with phosphoric acid. An additional phosphoric acid etching of enamel should be considered when using self etch adhesives.

Erhardt *et al.*2004[43] evaluated the influence of phosphoric acid pretreatment on shear bond strength of two self-etching bonding systems to enamel and dentin. Clearfil Liner Bond and One Up Bond were the two self etch adhesives used with and without phosphoric acid etching. The results of the shear bond strength test concluded that use of self-etching systems in composite-to-enamel bonding restorative techniques still needs improvement when compared with the high bond strengths obtained with phosphoric acid treatment. However, lower shear bond strengths were observed in dentin when phosphoric acid was used in association with either adhesive system.

Stewardson *et al.*2004[11] in an *in vitro* study evaluated the effectiveness of Systemp desensitizer (Ivoclar Vivadent), when used both with and without an acid-etch step, in the treatment of patients with dentine hypersensitivity in UK dental practices. Reports show that Systemp desensitizer containing methacrylate are effective in reducing pain from dentine hypersensitivity. It is concluded that Systemp desensitizer was effective in reducing pain from dentine hypersensitivity in the patients treated, and this finding was unaffected by whether or not the tooth was acid-etched prior to application of the reagent.

Ritter *et al*.2004[44] studied the effect of different rewetting techniques on dentin shear bond strength .An evaluation of four dentin desensitizer on the shear bond strength of three bonding system was done. The results concluded that application of gluma desensitizers significantly affect the shear bond strength of both Opti bond FL and Xeno III; M.S coat significantly decreased the shear bond strength of Xeno III; The shear bond strength of clearfil SE bond was not affected by any of the desensitizing pre-treatment; Tublicid and Vivasens do not alter the adherence of both Opti bond FL, Clearfil SE bond and Xeno III.

Arrais *et al.*2004[45] in a study evaluated the features of dentinal tubules occlusion following application of three commercially available desensitizing agents: potassium oxalate-based / Oxa-Gel , HEMA and Glutaraldehyde-based / Gluma Desensitizer and acidulated phosphate fluoride-based / Nupro Gel .According to the SEM analysis, all desensitizing agents were able to occlude the dentinal tubules.

Atash *et al*.2005[46] evaluated the bond strengths of eight contemporary adhesives to enamel and to dentine in an *in vitro* study on bovine primary teeth. The tested adhesives were: Clearfil SE bond (SE); Adper Prompt L Pop (LP); Optibond Solo Plus Self-etch (OB); AdheSE (AS); Xeno III (XE); Scotch Bond 1 (SB); Etch & Prime 3·0 (EP); and I Bond (IB).The shear bond strength analysis revealed that the highest shear bond strength was achieved by SE on enamel and dentine, and the lowest by IB on enamel and EP on dentine. The highest tensile bond strength was obtained by SE on enamel and dentine, and the lowest by EP. Shear bond strengths were significantly higher on enamel when compared to dentine for five of the eight adhesives systems, and tensile bond strengths were significantly higher on enamel when compared to dentine for all but two systems.

Lehmann *et al*.2005[47] studied the effect of four dentin desensitizers MS Coat, Viva Sens, Tubulicid, Gluma on the shear bond strength of three bonding systems Optibond FL, Clearfil SE Bond, Xeno III. He concluded that Viva Sens and Tubulicid did not decrease shear bond strength of the adhesive systems whereas MS coat and Gluma widely affected the dentine surface. Among the adhesive systems Clearfil SE Bond was not affected by the different desensitising agents**.**

Satoa *et al.*2005[48] in a study compared depth of dentin etching and resin infiltration with single-step adhesive systems. The purpose of this study was to use micro-Raman spectroscopy and scanning electron microscopy (SEM) to investigate the extent of resin penetration into etched dentin with single-step adhesive systems. They reported that the dentin–resin interface of single-step adhesive systems showed a gradual transition in the relative amount of adhesive from the resin side to dentin side. The widths of resin penetration into demineralized dentin detected by Raman microscopy were greater than those obtained by the morphological analysis using SEM.

Yiu *et al.*2005[49] in an *in vitro* study evaluated the micro tensile bond strength of 4 single bottle total etch adhesives to dentin pretreated with oxalate desensitizer. The results concluded that bond strength of Opti bond and Prime & Bond were significantly lower in oxalate pretreated specimen compared to the one step and single bond adhesive.

Soares *et al.*2006[50] in an *in vitro* study evaluated the effect of desensitizer and rewetting agent on dentin shear bond strength of three adhesives namely Gluma one bond, Single bond and One step. The samples were treated with and without a desensitizer Gluma and a rewetting agent Aqua prep. They concluded that the use of desensitizer and rewetting agent does not compromise the bond strength when they are compatible with the adhesive system used.

Maurin *et al.*2006[51] in an *in vitro* study evaluated shear bond strength of total etch three step and two self etching one step dentin bonding system, three dentin bonding agents were used: - scotch bond multipurpose plus (3M ESPE), a three step conventional adhesive system; prompt L pop (3M ESPE), two one step self etching primer adhesive system. It was concluded that Prompt L pop 2 showed high bond strength compared to other dentin bonding agents.

Qin *et al.*2006[52] did a study in which Fourier-transform (FT)-Raman and infrared (IR) spectroscopy were employed to investigate the function of the aqueous 2 hydroxyethyl methacrylate (HEMA)/Glutaraldehyde (GA) solution (Gluma) as a desensitizer.It was concluded that when Gluma is applied in vivo, two reactions occur. First, GA reacts with part of the serum albumin in dentinal fluid, which induces a precipitation of serum albumin. Second, the reaction of GA with serum albumin induces the polymerization of HEMA. This study proved Glutaraldehyde as an effective fixative or flocculating agent that can create a coagulation plug inside the dentinal tubules, thus readily reducing or totally eliminating tooth sensitivity. This precipitate thus would theoretically reduce the positive pressure fluid flow of the dentin, which might increase or stabilize the dentin bond long-term.

Awang *et al.*2007[53] studied the effect of dentine desensitizer MS Coat on shear bond strength of Prime and Bond NT and concluded that shear bond strength of Prime & Bond NT (Dentsply,USA) adhesive system will be reduced if dentin surface is treated with MS Coat (Sun Medical,Japan) desensitizing agent.

Duran *et al.*2005[54] evaluated *in vitro* dentin permeability of two-hydroxyl ethyl methacrylate (HEMA) based desensitizing product using split chamber following in vivo application in the dogs. Health-dent, Gluma desensitizing agents and Single bond was applied to respective quarter of the tooth. The data were expressed as hydraulic conductance (Lp). The result of the study was that the topical application of desensitizing agents leads to decrease in dentin permeability in the dog model. The Gluma desensitizing provides more long lasting tubules occluding effect than the other materials tested in this model.

Aranha *et al.*2006[55] evaluated the influence of desensitizing procedure on dentin bond strength. Forty bovine incisors were used, divided into four groups: G1: control, G2: Gluma desensitizer, G3: Oxa Gel; G4: Low intensity laser.After desensitizer application composite resin blocks were bonded to dentin and were subjected to universal testing machine. The results showed that except Gluma, all experimental groups showed significantly lower bond strength than control specimens. It was concluded that Gluma desensitizer did not detrimentally influence the bond strength values.

Pires *et al* .2007[56] investigated the influence of surface treatment and bonding agents on the bond strength of indirect composite restorations cemented with a resin based cements. Total etch adhesive and self etch adhesive were used. The results showed that One up bond F and surface treated specimen with biosilicate showed statistically significant higher bond strength mean than the other groups. It was concluded that use of desensitizing agent did not affect negatively the bonding of the indirect composite restoration to dentin.

Bradna *et al.*2008[57] did a study to estimate the *in vitro* reliability of typical self-etching and etch-and-rinse adhesives of various application protocols. The following adhesives were applied on flat dentin surfaces :self-etching two-step adhesives: AdheSE , Clearfil SE Bond , OptiBond SE ; one-step adhesives: Adper Prompt L-Pop , Adper Prompt , and Xeno III ; all-in-one adhesive: iBond ; etch-and-rinse three-step adhesives: OptiBond FL , two-step Gluma Comfort Bond , Excite and Prime & Bond NT .The results were analyzed with a nested ANOVA (adhesive, type of adhesive) followed by the Fisher post-hoc tests of group homogeneity at alpha = 0.05. A two-parameter Weibull distribution was used to calculate the critical shear bond strength corresponding to 5% probability of failure as a measure of system reliability.It was concluded that pronounced differences in the critical shear bond strength suggest reliability variations in the adhesive systems tested, which originate from chemical composition rather than type of adhesive.

Hegde *et al*.2008[58] in a study assessed the shear bond strength of Total etch Prime and Bond NT and self etch newer dentin bonding agents Clearfil S3, Xeno III Bond, Clearfil Protect Bond and G Bond used to bond composite resin to dentin, and to compare the difference in the shear bond strengths of the self etch newer dentin bonding agents The total etch adhesive showed higher shear bond strength than self etching adhesives ($P<0.001$). The results concluded that all the adhesive agents evaluated showed optimal shear bond strength 17-20 MPa, except G bond. However, shear bond strength of composite resin to dentin is better with one bottle total etch adhesive than with the newer self etching bonding agents.

Huh *et al*. 2008[59] in a study examined the effect of the previous application of desensitizers on the shear bond strength of one resin cement using self-etching primer to dentin. The dentin desensitizers used were SuperSeal , MS-Coat, Gluma and Copalite Varnish. Among the four dentin desensitizers, Superseal was the only one that did not interfere with the process of resin bonding. The other dentin desensitizers that contained a resin ingredient interfered with resin retention.

Auschill *et al*.2009[3] in a clinical study evaluated the appearance of postoperative sensitivity after composite treatments and the stimuli that may have caused it. A total of 600 teeth in 231 patients was included in this study and the bonding system used was Optibond FL and the nanofilled composite Ceram X. The results of the study showed that the clinical cavity depth turned out to be the only factor to have a significant influence on the appearance of postoperative sensitivity: caries profunda showed a four times higher risk of failure, while cavities with pulp exposure had a 14 times higher failure risk compared to restorations that were localized in the dentin. With regard to the type of sensitivity, no patients reported sensitivity to sweet/sour; most of them described their sensitivity as sharp/dull.

Dundar *et al*.2010[60] evaluated the influence of fluoride and triclosan based desensitizing agents on adhesion of resin based cements to dentin. Ceramic discs were adhered using Duolink and Variolink cement to the desensitized dentin. Variolink group showed no statistical difference with both desensitizers but in Duolink group fluoride showed significantly higher result than those in triclosan and control. Hence it was concluded that cohesive failure were more commonly observed with fluoride in Variolink and adhesive failure is more frequent observed in Duolink group.

Masanori *et al.*2007[61] in a study investigated whether a desensitizing agent (GLUMA Desensitizer) containing Glutaraldehyde and HEMA improved the bond strength and bonding durability of a self-etching primer adhesive to Er:YAGirradiated dentine. The results of the study concluded that application of GLUMA Desensitizer to Er:YAG -irradiated dentine increases the bond strength and durability of the self-etching priming adhesive used.

Dhawan *et al*. 2008[62] in an *in vitro* study compared the tensile bond strength of three different generation bonding agents to dentin using one composite resin and scanning electron microscopic study (SEM) of hybrid layer. Dentin conditioning with single bond (5th Generation) revealed better bond strengths as compared to scotch bond multipurpose (4th generation) and Prompt-L-Pop (6th generation). SEM evaluation of hybrid layer reveals that Single bond has shown a thicker hybrid layer comparing to other adhesives.

Ammar *et al.*2009[63] in a study investigated the effect of three different cross-linking agents—Glutaraldehyde , grape seed extract , and Genipin , a Gardenia fruit extract natural cross-linker—on resin-dentin tensile bond strengths (TBS). and concluded that the chemical modification to the dentin matrix promoted by Glutaraldehyde and Grape Seed extract , but not Genipin resulted in significantly increased bond strengths. The application of selective collagen cross-linkers during adhesive restorative procedures might be a new approach to improve dentin bond strengths.

Niazy *et al.* 2009[64] in an *in vitro* study evaluated the effect of application of an oxalate desensitizing agent, adhesive system or their combination on the permeability of dentin. The ultra-morphology was also studied using scanning electron microscope (SEM). Results revealed that all the tested dentin treatments significantly reduced the dentin permeability. SEM showed reduction of dentinal tubules patency for all tested materials. It was concluded that using either oxalate desensitizing agent or an adhesive system or their combination is effective in reducing the permeability of dentin and the patency and the number of dentinal tubules have direct effect on the permeability of dentin.

Sevimay *et al.*2009[65] conducted a study to evaluate the bond strength of composite resin on dentin surfaces that have been treated with different desensitizing agents: Systemp Desensitizer, Hybrid Bond, BisBlock, Gluma Desensitizers. Study concluded that specimens treated with desensitizers yield significantly lower mean bond strength except Systemp Desensitizers which did not detrimentally influence the bond strength.

Yaseen *et al.* 2009[66] did an *in vitro* study to compare and evaluate shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth. This study revealed that ClearfilS3 (seventh generation) could be of greater advantage in pediatric dentistry than Contax (sixth generation) because of its fewer steps and better shear bond strength in dentin of both primary and permanent teeth.

Christina *et al*.2010[67] assessed the influence of the topical application of two different desensitizing agents on dentin permeability and dentinal tubule occlusion and it was concluded that 2% nitrate potassium plus 2% sodium fluoride gel and 5% fluoride varnish decreased the dentin permeability, although they produced only partial dentin tubule surface occlusion. Repeated application of the desensitizing agents may possibly contribute to higher clinical effectiveness in dentin tubule occlusion.

Sailer *et al.*2010[68] investigated the bond strength of two universal resin cements to dentin after surface treatment. The dentin treatment include desensitizer

(Gluma, Syntac Primer) and dentin sealing by means of bonding agents (Heliobond, Clearfil SE Bond). The results showed that both cements exhibited significantly lower bond strength to freshly ground dentin than the control cement and sealing method showed significantly increased bond strength of both test cements. In was concluded that desensitizing or sealing of dentin have a beneficial effect on the bond strength of universal resin cements.

Ishihata *et al*.2011[69] in a study investigated dentin permeability after application of Gluma desensitizer and aqueous solutions of Glutaraldehyde and HEMA, respectively. The results showed that permeability decreased as a result of a reaction between Glutaraldehyde and albumin (protein precipitation) and secondly from induction of HEMA polymerization.

Kulunk *et al* .2011[9] evaluated the effects of different desensitizing agents on the shear bond strength of adhesive resin cement to dentin. The desensitisers used in the study were one containing sodium and calcium fluoride in cellulose alone, hydroxyethyl methacrylate (HEMA), benzalkonium chloride and sodium fluoride, HEMA and Glutaraldehyde, an ormocer-based or a resin-based dentin desensitizer. The results showed that the lowest bond strength was in the group treated with desensitizing agent containing sodium and calcium fluoride and the highest bond strength was from the group treated with desensitizing agent containing HEMA and sodium fluoride. Also the desensitizing agents containing sodium and calcium fluoride reduced the bond strength of adhesive resin cement.

Ravikumar *et al.* 2011[70] performed an *in vitro* study was to determine shear bond strength of two different bonding agents with two different desensitizers -Gluma desensitizer, and Vivasens desensitizer. Major group I was treated with Gluma comfort bond . Major group II was treated with Prime and Bond NT . The samples were thermo cycled and shear bond strength was evaluated using Instron machine. The specimens with Gluma desensitizer showed the highest shear bond strength.

Veerakumar *et al* .2011[71] in an *in vitro* study compared the inter-facial micromorphology of Prime and Bond and Prompt-L-Pop in primary and permanent teeth. The observation by SEM shows that Prime & Bond has better sealing ability than Prompt-L-Pop in both permanent and primary teeth. Prime and Bond showed no inter-facial gap in both permanent & primary teeth. Sealing capacity of Prompt-L-Pop is lower in permanent teeth than in the primary teeth.

Bhatia *et al*.2012[72] studied the effect of Sensodent and Denshield on shear bond strength of Single Bond and Prime And Bond NT and results of shear bond strength analysis concluded that the shear bond strength of adhesive systems is not reduced following application of desensitizers. The result of the stereomicroscopic examination revealed that the predominant mode of failure in all groups was adhesive (at interface) (31 samples), while 21 samples showed mixed failure.

Adebayo *et al*.2012[73] aimed to evaluate the association between the fracture toughness of two nanofilled-hybrid resin composites (Clearfil Majesty Esthetic ; EsteliteS) and their bond strengths to enamel and dentine mediated by a self-etching primer system (Clearfil SE Bond). The results proved that both enamel and dentine, resin composite fracture toughness affected neither TBS nor SBS to enamel or dentine.

Pei *et al*.2013[74] in an *in vitro* study evaluated the bonding performance of two self-etch adhesives containing functional monomers namely Clearfil S_3 bond and G-Bond to dentine pretreated with three new calcium-containing desensitizers which were an arginine–calcium carbonate containing polishing paste, a casein phosphopeptide–amorphous calcium phosphate- containing paste, and an experimental hydroxyapatite paste, respectively .Based on the results, it was concluded that these calcium-containing pastes might be recommended for adhesives with a suitable pH and containing functional monomers such as 4-MET (G-Bond) in clinical practice where both improved adhesion and desensitizing effects are expected. Also, desensitizer application in association with a compatible adhesive system should be used when endeavoring to control hypersensitivity without adverse interference in bonding.

Ding *et al*.2014[75] in an *in vitro* study evaluated the effect of desensitizing pretreatments on the micro-tensile bond strengths (μTBS) to eroded dentin and sound dentin and reported that Pretreatment with Gluma increased the μTBS of Single Bond 2 for eroded and sound teeth. CO2 laser irradiation weakened bond performance for sound teeth but had no effect on eroded teeth.

Hassan *et al*.2014[1] in an *in vitro* study assessed the effect of different disinfecting agents on bond strength of resin composites by using Prime and Bond 2.1 and Adper. Shear bond strength between dentin and resin composite was measured using Universal Testing Machine followed by fracture mode evaluation. The results of the study proved that surface treatment of dentin before bonding application has a great effect on shear bond strength between resin composite and dentin surface and etch-and-rinse adhesive recorded statistically nonsignificant higher shear bond strength mean value than self-etching adhesive. All groups showed percentage of adhesive failures but it was observed that the failure mode was predominantly adhesive for control group with increased percentage of mixed failure for groups of disinfectants.

Sancakli *et al.*2014[76] in a clinical study evaluated the post‑operative sensitivity of occlusal restorations using different dentin adhesives performed by an undergraduate and a post‑doctorate dentist. They observed that operator skill and experience appears to play a role in determining the outcome of postoperative sensitivity of multi‑step adhesive systems although the postoperative sensitivity was low. It is suggested that the less experienced clinicians (rather than experienced clinicians) should better use the self‑etching dentin bonding systems with reduced application steps to minimize the potential risk of postoperative sensitivity of dental adhesives.

Jose *et al* .2011[77] conducted a study to investigate the effect of a desensitizer on the degree of conversion of two bonding resin using fourier transform infrared spectroscopy. Total etch and self etch adhesive resins were used and which were further subdivided into with or without desensitizer. The results showed that group with desensitizer showed a significantly higher degree of conversion compared to without desensitizer. It was concluded that combination of bonding resin and desensitizer showed better control of postoperative sensitivity.

Porto *et al.*2012[78] in a bibliographic review identified the causes of post-operative sensitivity in resin composite restorations and how it can be avoided so that professionals can use this information to reduce the occurrence of this inconvenience in their daily practice. There are various causes of post-operative sensitivity in direct resin composite restorations related to failures in diagnosis and indications for treatment and/or cavity preparation, the stages of hybridization of hard dental tissues, insertion of the material, and finishing and polishing the restoration. To avoid or minimize the occurrence of postoperative sensitivity, it is imperative to make a good diagnosis and use the correct technique at all stages of the restorative procedure. The recommendations for avoiding or minimizing postoperative sensitivity involve all the principles for attaining excellence in restorative dentistry; that is, making a good diagnosis before performing the restoration; analysing the initial health of the pulp and periapical region; the use of new burs with abundant cooling; use of adequate isolation to prevent contamination; not dehydrating dentin with excessive drying; strictly following all the criteria indicated in the stages of hybridization, insertion, finishing, polishing and occlusal adjustment of the restoration.

Cavalcanti *et al*.2013[79] evaluated the effects of dentin conditioning on the bond strength of total etch and self etch adhesive system. All specimens were randomly divided into four groups and micro tensile bond strength was measured using universal testing machine. According to the results, control group with total etch adhesive showed higher bond strength compared to others. It was concluded that dentinal sensitivity is relieved by occlusion of dentinal tubules which in turn reduced the bond strength.

Andreatti *et al*.2014[80] conducted a study to analyze whether the prior use of desensitizing agents interferes with the bond strength of resin restorative materials. Adhesive systems used in the study were Scotchbond Multipurpose and Clearfil SE Bond and their association with bioglass or arginine was tested. Bond strength was assessed by a microshear mechanical test and fracture pattern analysis was done by means of optical microscopy, results of which showed a predominance of mixed type fractures, with the exception of the Control group, where adhesive fractures predominated. It is concluded that arginine did not interfere with the bond strength with dentin, while the use of Biosilicate tended to strengthen the bond between dentin and the adhesive systems used.

Makkar *et al.*2014[81] in an *in vitro* study evaluated the effect of different dentin-desensitizing treatments on the tensile bond strength of composite restoration and concluded that dentrifice and laser pre-treated dentin has lower tensile bond strength with resin composites as compared to dentin that is untreated.

Margvelashvili *et al.*2014[82] in a study assessed the bonding potential of recently introduced all-in-one adhesives to ground enamel. The microtensile test was used to evaluate the bond strength of the one-bottle self-etch adhesives Bond Force (Tokuyama), AdheSE One (IvoclarVivadent) and Xeno V (Dentsply), in comparison with the etch-and rinse adhesive Prime & Bond NT (Dentsply). The statistical analysis demonstrated that the bond strength achieved by Bond Force was similar to that of the control adhesive, whereas for AdheSE One and Xeno V the bond strength was significantly lower than for Prime & Bond NT, it can be concluded that the milder self etch adhesive has given higher bond strength values.

MATERIALS & METHODS

MATERIALS USED IN THE STUDY :

1. Self cure acrylic resin- Dental Products of India, Mumbai India.
2. 37 % Phosphoric acid Etch Gel- D-tech dental technologies,Pune, India.
3. Prime and Bond NT- Dentsply, Konstanz, Germany.
4. Xeno V^{+} - Dentsply, Konstanz, Germany.
5. Futurabond DC -Voco, Cuxhaven, Germany.
6. Systemp -IvoclarVivadent, Schaan, Liechtenstein, Switzerland.
7. Distilled water - Nice Chemical Laboratory Supplies Ltd, Kochi, India.
8. Resin composite Filtek™Z350 XT- 3M ESPE Dental products, St. Paul,MN,U.S.A.
9. Silicon carbide paper- Moyco Precision Abrasives, Montgomeryville, PA, U.S.A.
10. Mylar Strip - Samit Products, New Delhi, India

EQUIPMENTS/ INSTRUMENTS USED IN THE STUDY:

1. Micromotor Straight Hand piece-NSK, Japan
2. Diamond disc – SS White, USA.
3. Composite light curing unit – Dentsply, Milford, Detroit, USA.
4. Universal testing machine – Model 3345;InstronCorp,CantonMass,USA.
5. Teflon coated composite instrument- GDC,India.
6. Aluminium metal mould.
7. Stainless steel band-Denta, India.

METHODOLOGY:

Specimen preparation

Sixty recently extracted human maxillary premolars for orthodontic purpose and which were free of caries, cracks, wear lesions or developmental enamel defects were used for the study. The teeth were thoroughly hand‑scaled and stored in distilled water (Nice Chemical Laboratory Supplies Ltd, Kochi, India). The specimens were prepared within one month of teeth extraction. The teeth were taken out of distilled water and the roots were sectioned off with a diamond disc (SS White, USA). The occlusal surface of the crowns was sectioned with the diamond disc to expose the superficial dentin surface. Each tooth was then embedded into a rectangular metal mould of 1 cm × 4 cm using self cure resin (Dental Products of India, Mumbai, India) such that the exposed occlusal dentin surface faced upwards. The metal moulds with the acrylic resin were then immersed in water to dissipate the exothermic heat of polymerization, thus reducing damage to the test specimens. All the prepared specimens were then stored in distilled water until use.The stored specimens were retrieved, cleaned, and the dentin surface was polished with the help of wet 600, 800, 1200 grit silicon carbide paper (Moyco Precision Abrasives, Montgomeryville, PA, U.S.A.).This was done to create a smooth and flat surface for treatment and bonding.The specimens were randomly divided into six groups of ten specimens each.

Groups used in the study:

CONTROL GROUPS

Group I: Prime and Bond NT

Group II: Xeno V^+

Group III: Futurabond DC

EXPERIMENTAL GROUPS

Group IV:Systemp + Prime and Bond NT

Group V: Systemp + Xeno V^+

Group VI:Systemp+Futurabond DC

Bonding procedure:

In all the groups the flattened dentin surface was etched with 37% phosphoric acid gel (D-tech dental technologies, Pune, India) for 15 s, then rinsed with water for 20 s, and finally blot dried with moist cotton pellet, leaving a moist glistening surface.

In Group I , two coats of Prime and Bond NT (Dentsply, Konstanz Germany) bonding agent was applied to dentin with the applicator brush and light cured with the light curing unit (Dentsply, Milford, Detroit USA) according to manufacturer's instructions.

In Group II, two coats of XenoV^+(Dentsply, Konstanz Germany) bonding agent was applied to dentin with the applicator brush and light cured according to the manufacturer's instructions.

In Group III, two coats of Futurabond DC (Voco, Cuxhaven, Germany) bonding agent was applied on dentin with the applicator brush and light cured according to the manufacturer's instructions.

In Groups IV, V and VI, Systemp desensitizer (Ivoclar Vivadent, Schaan , Liechtenstein, Switzerland) was applied to dentin for 10s with the help of an applicator brush and was allowed to remain on the tooth surface for 20 s. Then the area was lightly dried with an air syringe. Prime and Bond NT, Xeno V^+, Futurabond DC was then applied to dentin of Groups IV, V, VI respectively. Following the application of bonding agent/ Systemp desensitizer, Shade A2 of Filtek Z350 XT(3M ESPE Dental products, St. Paul, MN, U.S.A) composite resin was dispensed with a Teflon-coated instrument (GDC, India) and condensed into the mould of 5mm diameter and 4mm height prepared using stainless steel bands (Denta, India) of size 0.180 x 0.005 which were placed on the exposed dentine surface. Any excess composite was wiped away with the same instrument.Each increment of 2mm of composite was light cured for 40 s. A Mylar strip (Samit Products, New Delhi, India) was adapted over the top surface of composite and light cured for 40 s. The stainless steel bands were cut using a scalpel and removed.The test specimens were stored in distilled water for seven days before being subjected to shear bond strength testing.

Shear bond strength testing:

Each specimen was placed in between the jigs of the universal testing machine (Model 3345;Instron Corp,Canton,Mass,USA). A knife‑edge shearing chisel was engaged at the dentin–composite interface and force was applied perpendicular to the long axis of the specimen.The equipment was operated at a crosshead speed of 1 mm/min and the load to debond the specimens was recorded in Newtons (N). The shear bond strength (mega pascals (MPa)) was calculated by the ratio of the maximum load (Newtons) to the cross-sectional area of the bonded interface (mm^2).

Statistical method of analysis:

The values obtained were tabulated and statistically analysed by Statistical Package for Social Sciences (SPSS) version 16.0. The data was expressed in its mean and standard deviation. Unpaired sample‘t’ test was applied to find the statistical significance between the experimental and control groups. One- way analysis of variance (ANOVA) followed by post hoc (Dunnet ‘t’ test) was applied for multiple comparisons. P value less than 0.05 ($P<0.05$) was considered statistically significant at 95% confidence interval.

RESULTS & OBSERVATIONS

RESULTS

Table-1- shows mean shear bond strength (MPa) values of different adhesive systems of all the six groups. The adhesives used in Group I is Prime and Bond NT, Group II is Xeno V^+ and Group III is Futurabond DC. These are the control groups without pretreatment with a dentin desensitizer Systemp. Groups IV, V, VI are the experimental groups with a prior treatment with a dentin desensitizer followed by the use of adhesives Prime and Bond NT, Xeno V^+ and Futurabond DC respectively.

Table-2- shows comparison of mean shear bond strength (MPa) values between the groups – Group I and Group IV –Prime and Bond NT when used without and with a desensitiser Systemp. The mean shear bond strength (MPa) value as observed for Group I is 15.07±0.31 MPa and Group IV is 16.28±2.63 MPa. The P value is less than 0.05 ($P<0.05$) is significant when Group-I is compared with Group-IV.

Table-3 – shows comparison of mean shear bond strength (MPa) values between the groups – Group II and Group V-Xeno V^+ used alone and with Systemp. The mean shear bond strength (MPa) value as observed for Group II is 14.47±1.31 MPa and Group V is 12.31±1.13 MPa. The P value is less than 0.05($P<0.05$) is significant when Group II is compared with Group-V.

Table-4 – shows comparison of mean shear bond strength (MPa) values between the groups – Group III and Group VI- Futurabond DC used alone and with Systemp. The mean shear bond strength (MPa) value as observed for Group III is 15.47±2.43 MPa and Group VI is 15.15±0.79 MPa. The P value is greater than 0.05 ($P>0.05$) is not significant when Group III is compared with Group-VI

Table-5 – shows comparison of mean shear bond strength (MPa) values of Group I with Group II and Group III. The mean shear bond strength of (MPa) Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (XenoV$^+$) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa. The result is significant when Group I is compared with other two groups (P<0.05).

Table-6 – shows comparison of mean shear bond strength (MPa) values of Group II with Group I and Group III. The mean shear bond strength (MPa) of Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (Xeno V$^+$) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa. The result is significant when Group II is compared with other two groups (P<0.05).

Table-7 – shows comparison of mean shear bond strength (MPa) values of Group III with Group I and Group II. The mean shear bond strength (MPa) of Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (Xeno V$^+$) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa. The result is significant when Group III is compared with other two groups (P<0.05).

Table-8 – shows multiple comparison of mean shear bond strength (MPa) values between Groups I, II and III. The mean shear bond strength (MPa) of Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (Xeno V$^+$) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa. P<0.05, is significant when Group-I is compared with other groups. P<0.05 is significant when Group-II is compared with other groups.

Table-9 – shows comparison of mean shear bond strength (MPa) values of Group IV (Systemp +Prime and Bond NT) with Group V and Group VI. The mean shear bond strength (MPa) of Group IV (Systemp +Prime and Bond NT) is

16.28±2.63 MPa, Group V (Systemp + Xeno V^+) is 12.31±1.131 MPa, and Group VI (Systemp + FuturabondDC) is 15.15±0.79 MPa. The result is significant when Group IV is compared with other two groups ($P<0.05$).

Table-10 – shows comparison of mean shear bond strength (MPa) values of group V (Systemp+ Xeno V^+) with Group IV and Group VI. The mean shear bond strength (MPa) of Group IV (Systemp +Prime and Bond NT) is 16.28±2.63 MPa, Group V (Systemp+ Xeno V^+) is 12.31±1.131 MPa, Group VI (Systemp+ Futurabond DC) is 15.15±0.79 MPa. The result is significant when Group V is compared with other two groups ($P<0.05$).

Table-11 – shows comparison of mean shear bond strength (MPa) values of Group VI (Systemp+ Futurabond DC) with Group IV and Group V. The mean shear bond strength (MPa) of Group IV (Systemp+Prime and Bond NT) is 16.28±2.63 MPa, Group V (Systemp +Xeno V^+) is 12.31±1.131 MPa, Group VI (Systemp+Futurabond DC) is 15.15±0.79 MPa. The result is significant when Group VI is compared with other two groups ($P<0.05$).

Table-12– shows multiple comparisons of mean shear bond strength (MPa) values between the Groups IV, V and VI. The mean shear bond strength (MPa) of Group IV (Systemp +Prime and Bond NT) is 16.28±2.63 MPa, Group V (Systemp +Xeno V^+) is 12.31±1.131 MPa, Group VI (Systemp+Futurabond DC) is 15.15±0.79 MPa. $P<0.05$ is significant when Group-IV is compared with other groups. $P<0.05$, is significant when Group-V is compared with other groups.

Table 13- shows multiple comparisons of mean shear bond strength (MPa) values between the groups.This table shows the significance of each group with respect to the P values. P value less than 0.05 ($P<0.05$) was considered statistically

significant at 95% confidence interval. The mean shear bond strength (MPa) of Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (Xeno V^+) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa. The mean shear bond strength (MPa) of Group IV (Systemp +Prime and Bond NT) is 16.28±2.63 MPa, Group V (Systemp+ Xeno V^+) is 12.31±1.131 MPa, Group VI (Systemp+Futurabond DC) is 15.15±0.79 MPa.The results of the statistical analysis shows that $P<0.05$, is significant when Group-I is compared with other groups. $P<0.05$, is significant when Group-II is compared with other groups. $P<0.05$, is significant when Group III is compared with other groups. $P<0.05$, is significant when Group-IV is compared with other groups. $P<0.05$,is significant when group-V is compared with other groups.

OBSERVATIONS

Shear bond strength in the control groups:

The control groups are Group I - Prime and Bond NT, Group II- Xeno V^+ and Group III -Futurabond DC. These samples are not treated with a dentin desensitiser Systemp. The maximum shear bond strength (MPa) values are shown in Group III where Futurabond DC was used as an adhesive to bond composite resin to dentin when compared to Group I (Prime and Bond NT) and Group II (Xeno V^+).The least bond strength (MPa) is shown by Group II (Xeno V^+).

Shear bond strength in the experiment groups:

The experiment groups are Group IV (Systemp+ Prime and Bond NT), Group V (Systemp+ Xeno V^+), Group VI (Systemp+Futurabond DC).These samples were treated with a dentin desensitiser Systemp before application of adhesives. The maximum shear bond strength (MPa) values are shown in Group IV compared to Group V and Group VI .The least bond strength (MPa) is shown by Group V.

Maximum and minimum shear bond strength among all groups:

The results show that the maximum shear bond strength (MPa) among all groups is exhibited by Prime and Bond NT when used with Systemp (Group IV).The minimum shear bond strength (MPa) among all groups is exhibited by Xeno V^+ when used with Systemp (Group V).

Shear bond strength before and after treatment with dentin desensitizer Systemp:

The results show that the mean shear bond strength (MPa) of adhesives without application of dentin desensitizer Systemp is as follows: Group I (Prime and Bond NT) is 15.07±0.31 MPa, Group II (Xeno V^+) is 14.47±1.31 MPa, Group III (Futurabond DC) is 15.47±2.43 MPa.The mean shear bond strength (MPa) of adhesives after application of dentin desensitizer Systemp is as follows: Group IV (Systemp+ Prime and Bond NT) is 16.28±2.63 MPa, Group V (Systemp+Xeno V^+) is 12.31±1.131 MPa, Group VI (Systemp+Futurabond DC)is 15.15±0.79 MPa.The analysis of results shows that the mean shear bond strength (MPa) of Prime and Bond NT increased after application of a dentine desensitizer from 15.07±0.31 to 16.28±2.63 MPa. The mean shear bond strength (MPa) of Xeno V^+ decreased after application of dentin desensitizer from 14.47±1.31 to 12.31±1.131 MPa. The mean shear bond strength (MPa) of Futurabond DC decreased after application of dentin desensitizer from 15.47±2.43 to 15.15±0.79 MPa.

DISCUSSION

Prime and Bond NT showed an increase in bond strength after application of a dentin desensitizer. Xeno V^{+} showed a decrease in bond strength values after application of dentin desensitizer. The bond strength values of Futurabond DC exhibited a decrease after application of dentin desensitizer and were not statistically significant when compared before and after desensitizer application. Hence the study hypothesis that the use of a dentin desensitizer will enhance the bond strength of composite resin to dentin was partially accepted.

The clinical success of composite restoration depends on the adhesive system that provides durable bonding of composite and dentin, effectively sealing the margins of restoration, enhancing the retention, and preventing postoperative sensitivity and microleakage.[83]

Perhaps the most intriguing and challenging problem is post-operative dentin sensitivity and this is one of the disadvantages of using direct resin composites in posterior teeth.[84] After restorations with resin composite, especially in posterior teeth, clinical observation has shown that patients complain of dentinal sensitivity at different levels and in different situations. This is a common problem, even with no visible failures in the restoration.[78]

Pain is always a warning signal of possible aggression, and although it does not have a direct relationship with the pathological processes, it is one of the most common reasons for seeking dental treatment, either in public service or private clinics.[85]

Post-operative sensitivity in resin composite restorations is a common occurrence that causes discomfort in the patient although frequent; it has still not been fully explained.[78] The sensory potential of the pulp makes it capable of reaction with an immediate painful response, even when the stimulus is applied at a distance from the pulp tissue, such as in the superficial layers of dentin.[85]

Clinical studies on sensitivity arising after resin composite restorations have reported a frequent and very variable prevalence of between 0 and 50%, with predominance in posterior teeth and Class II restorations.[78] As the patient can have considerable discomfort, professionals are sometimes obliged to change restorations because of the inability to eliminate the problem.[86]

Post-operative sensitivity can be caused by multiple factors and does not originate from one isolated aspect. It results from the interaction between the restorative technique, the clinical condition of the tooth to be treated (health of the pulp and remaining hard dental tissue) and the restorative material. Therefore, there is a permanent and unpredictable possibility of the occurrence of sensitivity.[85]

The main morphological characteristic of dentin is that it is a tubular structure, filled with fluid, connecting the pulp to the enamel–dentine junction. The lumen of dentinal tubules is surrounded by thin cuffs of mineralized tissue, called peritubular dentin. The matrix interposed between this cylindrical structure, the intertubular dentin, contains around 30% by volume of mineralized collagen type I fibrils perpendicular to the long axis of the tubules.Much smaller quantities of collagen (10% by volume) are present in peritubular dentin.[87] Dentinal permeability is, therefore, a direct consequence of this structural pattern. The closer one gets to the pulp, the greater is the value of this porosity as well as the diameter of the tubules (2.5 μm close to the pulp; 1.2 μm in the intermediate region; 0.5 μm at the enamel–dentine junction). This explains the increase in dentin permeability in the area close to the pulp chamber.[78]

The widely accepted hydrodynamic theory proposed by Brännström and Ästron seeks to explain the painful phenomenon that occurs in dentin by the movement of fluid within the dentinal tubules after certain stimuli, which causes intratubular pressure changes, thus leading to excitation of the pulp nerve terminals, producing a sensation of pain.[85,88,89]

Various treatment modalities have been described to decrease the dentin sensitivity after a composite restoration. In the present study a newly developed tubule occluding desensitizing agent Systemp was used. It contains Glutaraldehyde and polyethylene glycol which was applied to seal dentinal tubules before bonding with adhesives. Their combined effectiveness ensures optimal sealing of the tubules. *In vivo* and *in vitro* studies have proven that effective and robust occlusion of dentinal tubules offers the greatest prospect for instant and lasting relief of dentin hypersensitivity The combination of polyethylene glycol dimethacrylate, which precipitates proteins and thus leads to local concentrations, and Glutaraldehyde, which establishes stable, covalent bonds to proteins, results in the formation of firm plugs of protein that seal the tubules. These plugs considerably reduce permeability and the incidence of dentinal sensitivity. [90]

However there are conflicting reports on the effect of tubule‑occluding desensitizing agents on bond strength of adhesive restoration. Hence this study was undertaken to evaluate if prior application of dentin desensitizer Systemp affected the bond strength of adhesives. Three adhesives were chosen for this study. They were

Prime and Bond NT, Xeno V^+ ,Futurabond DC from fifth , seventh and the recently introduced eighth generation of bonding agents respectively.

Maxillary premolars were preferred in this study as flat dentin surface could be prepared which would give a wider area of dentin to be treated and bonded to resin substrate, and also maxillary premolars are easily available after orthodontic extractions. 5mm diameter of stainless steel moulds were used so that it covers the maximum surface of tooth and with a height of 4 mm so that it gives sufficient amount of composite. Stainless steel bands were used to make the mould because of ease of fabrication, availability and ease of removal.

With reference to previous studies the exposed dentin surfaces of all the samples were acid etched with 37% phosphoric acid gel for 15 sec each. Kimochi *et al.* suggested that 37% phosphoric acid to be used in order to attain high tensile bond strength.[91] In 1955 Buonocore introduced the concept of acid etching, i.e. chemically treating the enamel to alter its surface characteristics to allow for adhesion of acrylic resins to the enamel surface of the tooth. Acid etching of the enamel gave 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.[92] Degree of surface etching and demineralization of enamel and dentin depend on the type of acid, the etching time, and the concentration of the etchant.[93,94,95,96] Normally, phosphoric acid at a concentration between 30-40% provided retentive surfaces .[93] Concentrations greater than 50% resulted in the formation of a monocalcium phosphate monohydrate that inhibits further dissolution, and in concentrations lower than 30% there forms a precipitate of dicalcium phosphate dehydrate that cannot be easily removed.[97,98] Originally, standard treatment time for enamel conditioning was 60 seconds. However studies by Barkmeier *et al*. have indicated that a 15-second etching time provides similar surface morphology and bond strength values.[99] Gwinnett and Kanca reported that conditioning dentin with 37% phosphoric acid for 15 seconds followed by a unique combination of hydrophilic primers and an ambiphilic bonding agent resulted in a gap-free interface between resin and tissue *in vivo* and *in vitro*.[100] The etchant used was in the gel form as it is better controlled and does not flow to unwanted areas as opposed to liquid form. Hence all samples in the present study were etched with 37% Phosphoric acid gel for 15 secs.

The success of dentin bonding has been believed to be dependent on the infiltration of resin monomers into acid etched dentin followed by polymerization in situ .[101,102] There are studies reporting different conclusions about the bonding effectiveness to dentin of a self-etch adhesive system when placed either with or without previous phosphoric acid etching.[103,104] A study which tested the effect of initial phosphoric acid etching on the bond strength of self-etch adhesive to dentin concluded that the acid etching should be limited to enamel because of impaired dentin bond strengths. [103]Another study reported no significant differences among different smear layer treatments with the same adhesive system.[104] The potential chemical interaction between the functional monomers and the residual hydroxyapatite depends on each adhesive, in accordance with its composition. This occurs because, as opposed to conventional adhesives that require phosphoric acid etching,the self-etching system demineralizes dentin only partially,leaving hydroxyapatite attached to collagen. [43] For single-step self-etch adhesives, little information is available concerning the removal of the smear layer with previous phosphoric acid etching to enhance bonding ability of the adhesives. [105] Acid etching removes the smear layer and smear plugs, opening dentinal tubules and demineralizing the peri- and intertubular dentin, thus increasing dentin permeability.[106] .Decalcification depth ranges from 2 to 4 μm and is affected by etchant ph, type, concentration, viscosity, and application time.[107] The bonding mechanism of conventional adhesives consists of micromechanical interlocking of resin monomer with the exposed collagen fibrils of wet demineralized dentin. Despite the profound changes that acid etching promotes in the chemical composition and physical properties of the dentin matrix, phosphoric acid has been widely used in restorative dentistry as an etching agent for both enamel and dentin. [108]In general, the effect of additional demineralization with phosphoric acid is expected to be dependent on aspects such as functional monomer composition and adhesive generation, since the properties and interactions taking place in adhesive interfaces created differently are also expected to vary.[109] However, since there is a high product-dependency aspect associated with the interactions taking place between the functional monomers and dental substrate, no definitive statements can be made as to effect of additional phosphoric acid etching on the dentin bond strength of different adhesive compositions.[110]

Systemp was applied on all the samples of the experiment groups according to the manufacturer's instructions. A study done by the Applied Testing Laboratory, Ivoclar North America reported that if Systemp desensitizer is applied after etching, the bond strength of adhesive tends to increase, while it decreases if the desensitizer is applied before the etching procedure.[90] This reaction may be attributed to the fact that Glutaraldehyde is capable of fixing the smear layer of prepared dentin which impairs the etchability of dentin.[111] Stewardson *et al*. in an *in vitro* study evaluated the effectiveness of Systemp desensitizer , when used both with and without an acid-etch step, in the treatment of patients with dentine hypersensitivity in UK dental practices.

Reports show that Systemp desensitizer containing methacrylate are effective in reducing pain from dentine hypersensitivity. It is concluded that Systemp desensitizer was effective in reducing pain from dentine hypersensitivity in the patients treated, and this finding was unaffected by whether or not the tooth was acid-etched prior to application of the reagent.[11] Sevimay *et al*. conducted a study to evaluate the bond strength of composite resin on dentin surfaces that have been treated with different desensitizing agents: Systemp Desensitizer, Hybrid Bond, BisBlock, Gluma Desensitizers. Study concluded that specimens treated with desensitizers yield significantly lower mean bond strength except Systemp desensitizer which did not detrimentally influence the bond strength.[65]

Prime and Bond NT is a single-bottle adhesive which belongs to the 5th generation of bonding agents. The adhesive works on the basis of Total Etch concept.It contains nanofillers that supposedly reinforce the adhesive layer in the bonding interface. It also contains urethane dimethacrylate (UDMA) and a dipentaerythritolpentacrylate phosphorous acid ester (PENTA). Urethane dimethacrylate is a hydrophobic monomer for proper polymerization and crosslinking that bonds to surface-bound hydroxyl groups through its urethane whereas PENTA, a weak acid, is an adhesion promoter that facilitates the penetration of resin monomers into dentin for micromechanical bonding.[112] It is a commonly used bonding agent and hence it was used in the current study.

Xeno V^+ is a self etch adhesive belonging to the 7th generation. Xeno V^+ is a one component self-etching dental adhesive designed to bond resin-based, light-curing direct restorative materials to enamel and dentin. Xeno V^+ does not need to be mixed. Although it is delivered as one component, it does not need to be stored in a refrigerator. The high tolerance of Xeno V^+ towards storage conditions of up to 24°C is obtained by using new monomers namely acryl resins with amide groups instead of ester groups , inverse functionalized phosphoric acid esters instead of ester functionalized phosphoric acid esters and the use of tertiary butanol instead of lower molecular weight alcohols, like ethanol, as a solvent . The second acidic monomer, the acryloylamino alkylsulfonic acid, is added to the formulation to increase the acidity, Acrylic acid, although only a weak acid, plays an important role in the interaction of monomers. As a small polar, but also a polymerizable monomer, it promotes the penetration of the bigger crosslinker monomers into the tooth substrate and is a wetting aid.[17]

The recently introduced eighth generation dentin bonding agent Futurabond DC, contains significant amounts of highly functional nano sized cross linking agents, the silica particles and has the advantage of being dual cured. It is a single use blister pack which has the property of being dual cured all in one.[12] It ensures a “stick immediately effect” which guarantees that the bond will not be blown out of the cavity while air drying. This ensures a superior marginal integrity and protection against sensitivities.[113]

Four factors normally influence the final strength of the union of composite resin to the dentine surface, namely wettability, stress setup by the setting contraction of the resin, filler composition of composite resin, bond strength of the adhesive.[81] Out of these factors, the role of bond strength of the material when bonded with different generation bonding agents with and without use of a dentine desensitizer was considered in this study.

All the adhesives were applied to the dentin samples with an applicator according to manufacturer's instructions. Composite was placed in 2mm increments. Eick and Welch suggested that applying the composite resin incrementally could reduce polymerization shrinkage stresses.[114] Curing period of 40 seconds for each 2 mm increment was observed to avoid uncured resin, as this would cause bonding failure at an undesired site during testing.

All specimens were kept in distilled water before testing to simulate the oral conditions.[62] A shear type of test was applied to test the bond strength. Shear bond strength test is a simple evaluation procedure used to test the adhesion of dental adhesives. [58]*In vitro* bond strength tests are useful and essential for predicting the performance of adhesive systems and possible correlation with clinical issues. So shear bond strength testing is done with a universal testing machine, Instron, which is conventionally popular for evaluating the adhesive ability of adhesive/restorative materials. Bond strength is the force per unit area that is required to break a bonded assembly with failure occurring in or near the adhesive/adherend interface.[46]

An instron universal testing machine (Model 3345;Instron corp,Canton mass,USA),with the knife edge placed as close as possible to the junction between the base and the cylinder, was used for testing. Specimens were mounted and the bonded composite cylinder was positioned horizontally, so that the shearing blade is perpendicular at composite-dentin interface. Each specimen was loaded until failure occured. Shear force required to debond the specimen was recorded. Debonding stress (in Megapascal) was then calculated by the ratio of maximum load (in Newton) to the surface area (mm^2) of prepared resin cylinder ($MPa = N/mm^2$). In a shear test, the bond is broken by a force working parallel to the tooth surface. Shear stress is considered to be more representative of the clinical situation .With the simple technique and relevant results, it is considered a benefit for the purposes of ranking and marketing. [58]

The shear bond strength values obtained were tabulated and statistically analyzed by Statistical Package for Social Sciences (SPSS) version 16.0. The data was expressed in its mean and standard deviation. Unpaired sample't' test was applied to find the statistical significance between the experimental and control groups. One-way analysis of variance (ANOVA) followed by post hoc (Dunnet 't' test) was applied for multiple comparisons. P value less than 0.05 ($P<0.05$) was considered statistically significant at 95% confidence interval.

The analysis of results in the control groups showed that the the maximum shear bond strength value of 15.47±2.43 MPa was exhibited by Group III (Futurabond DC) when compared to Group I (Prime and Bond NT) and Group II (Xeno V^+).The least bond strength value of 14.47±1.31 MPa was shown by Group II (Xeno V^+).

The analysis of results in the experiment groups showed that the maximum shear bond strength value of 16.28±2.63 MPa was exhibited by Group IV (Systemp+ Prime and Bond NT) compared to Group V (Systemp+Xeno V^+) and Group VI (Systemp+ Futurabond DC) .The least bond strength value of 12.31±1.131 MPa was shown by Group V (Systemp+Xeno V^+).

The results also confirmed that the maximum shear bond strength among all groups was exhibited by Prime and Bond NT when used with Systemp (Group IV).The minimum shear bond strength among all groups was exhibited by Xeno V^+ when used with Systemp (Group V).The analysis of results showed that the mean shear bond strength of Prime and Bond NT increased after application of a dentin desensitizer from 15.07±0.31 to 16.28±2.63 MPa. The mean shear bond strength of Xeno V^+ decreased after application of dentin desensitizer from 14.47±1.31 to 12.31±1.131 MPa. The mean shear bond strength of Futurabond DC decreased after application of dentin desensitizer from 15.47±2.43 to 15.15±0.79 MPa.

Among the experiment groups the maximum shear bond strength was exhibited by Prime and Bond NT when used with Systemp (Group IV) . This could be attributed to the concept of moist bonding related to total etch adhesives. Dentin dehydration compromises the infiltration of the adhesive resin because of the collapse of the acid exposed collagen network The classic frosted appearance of etched enamel is the ultimate clinical indication that the enamel was effectively conditioned. Since it is virtually impossible to air-dry the enamel without drying dentin simultaneously, this technique leads to dentin over-drying. It has been suggested that the inclusion of water in the adhesive may re-expand the collapsed collagen fibrils and facilitate the infiltration of the etched dentin by the resin acetone- or ethanol-based adhesives. Without water, it is essential to re-wet the etched dentin surface before the application of the adhesive.[23,115] Additionally, low amounts of water in the adhesive might not be sufficient to act as a self-contained re-wetting agent.[27]

Acetone has been reported by some authors to be a better solvent than water for the resin monomers, because it has the ability to displace water from the collagen network and facilitate saturation of the conditioned dentin with primer components. Glutaraldehyde present in Systemp may function as a re-wetting agent before the application of adhesive resins on etched dentin, as well as a desensitizing agent.

Clinically, this dual effect would be convenient.

Studies show that bond strengths of adhesives bonded to dentin surfaces previously treated with Glutaraldehyde are not adversely affected.[116,117]The application of Glutaraldehyde after etching of dentin has been shown to improve the efficacy of dentin bonding systems *in vitro*. The enhanced bond strength to dentin treated with glutaraldehyde after acid-etching is believed to be attributable to the collagen cross linking effect of glutaraldehyde. Preliminary research indicates that the treatment of etched dentin with Glutaraldehyde may contribute to the formation and stabilization of the collagen fibril-resin monomer hybrid layer by glutaraldehyde crosslinking of the acid-exposed collagen fibers. However, the effects of Glutaraldehyde on the bond strengths of bonding agents to dentin have not been studied when this material is used as a re-wetting agent.[118]

Ravikumar *et al.* performed an *in vitro* study to determine shear bond strength of two different bonding agents with two different desensitizers -Gluma desensitizer, and Vivasens desensitizer.The samples were thermo cycled and shear bond strength was evaluated using Instron machine. The specimens with Gluma desensitizer treated with Prime and Bond NT showed the highest shear bond strength.[2]

Another study by Bhatia *et al.* studied the effect of Sensodent and Denshield on shear bond strength of Single Bond and Prime and Bond NT and results of shear bond strength analysis concluded that the shear bond strength of adhesive systems is not reduced following application of desensitizers.[72]

Prime and Bond NT showed decreased bond strength in the control group as compared to the experiment group. This could be attributed to the inherent complexities of moist dentin bonding. Areas of excessive drying of dentin could have led to the collapse of collagen fibrils. Excessive drying and resultant desiccation of the dentin following acid conditioning results in collapse of the dentin demineralized zone, making it difficult for the hydrophilic resin primer to penetrate the filigree of collagenous fibers completely to the depth of the etched zone. Therefore, bonding to dry dentin results in incomplete formation of the hybrid layer by compromising the resin infiltration and impregnation of this acid conditioned layer. Bond strengths of resin to dried dentin consequently are lower, and failure might occur at the adhesive interface.[119,120] .Therefore, it is critically important to be able to successfully rehydrate the dentin prior to bonding if the cavity is air-dried following acid conditioning. Re-wetting following acid conditioning not only expands the demineralized collagen network but also increases the surface energy of the substrate, favoring the diffusion of the hydrophilic resin monomers into the etched zone.[121]The results are in accordance with the study done by Bansal *et al*. to evaluate effect of rewetting agents on the shear bond strength of different bonding agents when applied on dry dentin which proved that Prime and Bond NT had significantly lower bond strength when applied to dry dentin and same bonding agent showed better results when applied to moist dentin. It has been suggested that the inclusion of water may re-expand the collapsed fibrils and facilitate the infiltrations of etched dentin by the resin monomers.[122]

The results show that the minimum shear bond strength among all groups was exhibited by Xeno V^+ when used with Systemp (Group V).This could be attributed to the excess water in the etched dentin that can result in an inadequate bonding substrate. The adhesive resin may undergo phase separation of the hydrophobic components when too much water is present, resulting in resin globule formation.[23] This so-called overwet phenomenon is observed particularly when water-containing adhesives (i.e., hydrophilic resins dissolved primarily in acetone or ethanol but with water added as part of the solvent), are applied to an already wet surface.[123] Since clinically it is extremely difficult to determine the degree of wetness of the etched substrate, dentin drying before the application of the adhesive resin might be necessary to avoid excess water, requiring the use of a rewetting agent to re-expand the collagen network.[30] Xeno V$^+$ after application of desensitizer exhibited decreased bond strengths. Xeno V$^+$ contains a wetting aid in its formulation. The role of acrylic acid as the wetting aid may have led to overwetting of denting along with the desensitizer.

Margvelashvili *et al*. in a study assessed the bonding potential of one-bottle self-etch adhesives Bond Force (Tokuyama), AdheSE One (Ivoclar Vivadent) and Xeno V (Dentsply), in comparison with the etch-and rinse adhesive Prime & Bond NT (Dentsply). The statistical analysis demonstrated that the bond strength achieved by Bond Force was similar to that of the control adhesive, whereas for AdheSE One and Xeno V the bond strength was significantly lower than for Prime & Bond NT.[82] The study shows that Xeno V showed inferior results when compared to Prime and Bond NT which is similar to results obtained in the present study. Total etch Prime & Bond NT showed better bond strength compared to the self etching adhesives - Xeno V and Futurabond DC. This result was in accordance with Bouillaguet *et al.*, Chuang *et al.*, Kerby *et al.* who concluded that self etching adhesives have lower bond strength as compared to total etch bonding system.[33,124,125] Senawongse *et al*. also demonstrated that 2 self etching systems, One – up bond and Clearfil SE bond, had lower bond strength than did the total etch system Single bond. [126]

Futurabond DC exhibited the highest bond strength values in the control group which may be attributed to the nano sized cross linking agents present as claimed by the manufacturer. The significant amounts of highly functional nano sized cross linking agents, the silica particles may be responsible for the superior bond strength. Joseph *et al.* in a study evaluated bond strength of Futurabond DC in comparison with sixth and seventh generation bonding agents and proved that Futurabond DC showed superior results.[12] In the experiment groups Futurabond DC showed decreased values of shear bond strength after application of a desensitizer however it was not statistically significant. The minimum decrease in values can be attributed to excessive and additional rewetting provided by the desensitizer which led to overwetting and weakening of the resin dentin interphase.

Even though total etch adhesives recorded a higher shear bond strength with the desensitizer than the newer self etching bonding agents the existing self-etch adhesives are popular because they are easy to handle, convenient, and less confusing for the clinician than the multistep adhesive systems and also as their bond strength lies in the optimal range for clinical success.[127]

Postoperative sensitivity following application of posterior composite resin restorations is very common. Desensitizing agents that occludes dentinal tubules to some extent can significantly reduce fluid filtration across dentin and consequently lower the pain response by formation of firm plugs of protein that seal the tubules. These plugs considerably reduce permeability and the incidence of dentinal sensitivity. Hence the use of a dentin desensitizer before application of bonding agent and restoration with composite may reduce the postoperative sensitivity.

Bond strength studies are quite rough categorizing tools for evaluating the efficacy of bonding materials. Several factors influence *in vitro* bond strength to dentin, such as the type and age of the teeth, the degree of dentin mineralization, the dentin surface being bonded, the type of bond strength test (shear or tensile), the storage media, and the environmental relative humidity in substrates and testing conditions. These variations could be responsible for the high standard deviation and wide ranges obtained in the present study.[10]

Other variables like functional monomers, cross-linking monomers, solvents, inhibitors and activators may also differ in proportions and can affect bond strength. In brief, the amount of monomers, diluents and filler loads differs between products according to manufacturer's technology which is not well described in adhesive composition. Also little is known about the shrinkage and stiffness of these filled adhesives after polymerization. These factors could affect the shear bond strength significantly.[12] However, due to the inherent limitation of an *in vitro* study, the bonding and sealing ability of these adhesive systems to dentin warrant further investigation. Further clinical trials using different desensitizers and bonding agents may be necessary before a final conclusion on the effect of dentin desensitizer on dentin bond strength.

SUMMARY & CONCLUSION

Recent improvements in esthetic and adhesive dentistry, newer materials and esthetic demands of the patients have often led to the frequent use of composite restorations in posterior teeth, but a cardinal problem of post-operative sensitivity still persists. The sensitivity may last for a longer period of time which occasionally may result in the ultimate failure of the restoration. Post-operative sensitivity is related to various factors .Fluid filtration through dentinal tubules can cause a painful response. Tubule occluding agents are coming into use as they reduce the dentin permeability and associated sensitivity.

When using recently developed dentin adhesives, one of two strategies to interact with the dentin smear layer can be used: The total-etch technique or the self-etch technique. For those using the total-etch technique, the quality of the resin-dentin adhesion can be greatly affected by the duration of the acid-etching process and the amount of surface wetness present during the adhesive application. Self-etching adhesives use acidic monomers that simultaneously dissolve the smear layer and prime the dentin and enamel. The latest generation of all-in-one self-etching systems combines the etchant, primer, and adhesive in a single component result in a more uniform penetration of resin into the etched dentin maintaining a better seal, excellent clinical effectiveness with a reduced clinical application time and technique sensitivity. Within the clinical application technique, sensitivity discrepancies of the adhesive bonding strategies, clinical experience, and skill might also affect the performance of a restoration unless the standard instructions are strictly followed.

The present study was done to evaluate whether prior treatment of dentin with a dentin desensitizer Systemp would have any influence on the shear bond strength of composite to dentin using three bonding agents belonging to fifth, seventh and recently introduced eighth generation namely Prime and Bond NT, Xeno V^+ and Futurabond DC respectively.

Sixty recently extracted human maxillary premolars were used for the study. The occlusal surface of the crowns were sectioned to expose the superficial dentin surface and embedded into a rectangular metal mould of 1 cm × 4 cm using self cure resin .The specimens were randomly divided into six groups of ten specimens each. In all the groups the flattened dentin surface was etched with 37% phosphoric acid gel. In Group I, II and III two coats of Prime and Bond NT, XenoV^+, Futurabond DC bonding agent was applied on dentin respectively and light cured according to the manufacturer's instructions. In Groups IV, V and VI, Systemp desensitizer was applied to dentin for 10s with the help of an applicator brush and was allowed to remain on the tooth surface for 20 s. Prime and Bond NT, Xeno V^+, Futurabond DC was then applied to dentin of Groups IV, V, VI respectively. Filtek Z350 XT composite resin was condensed into the mould using stainless steel bands and was light cured for 40 s. The stainless steel bands were cut using a scalpel and removed. The test specimens were subjected to shear bond strength testing using the Instron Universal testing machine. The shear bond strength (mega pascals (MPa)) was calculated by the ratio of the maximum load (Newtons) to the cross‑sectional area of the bonded interface (mm^2).The values obtained statistically analysed by Statistical Package for Social Sciences (SPSS) version 16.0. The data was expressed in its mean and standard deviation. The analysis of results shows that the mean shear bond strength of Prime and Bond NT increased after application of a dentine desensitizer from 15.07±0.31 to 16.28±2.63 MPa,. The mean shear bond strength of Xeno V^+ decreased after application of dentin desensitizer from 14.47±1.31 to 12.31±1.131

MPa. The mean shear bond strength of Futurabond DC decreased after application of dentin desensitizer from 15.47±2.43 to 15.15±0.79 MPa.

Hence, within the limitations of this *in vitro* study it may be concluded that use of a dentin desensitizer Systemp has the ability to enhance the bond strength of Prime and Bond NT whereas the bond strength values of Xeno V^+ reduced considerably. Futurabond DC also showed decreased bond strength values after application of dentin desensitizer, however the results were statistically non significant. More clinical trials are needed to validate the findings.

TABLES

Table-1: Mean Shear bond strength (MPa) values of different adhesive systems in various groups

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)
Group-I	Prime and Bond NT	15.07±0.31
Group-II	Xeno V^+	14.47±1.31
Group-III	Futurabond DC	15.47±2.43
Group-IV	Systemp + Prime and Bond NT	16.28±2.63
Group-V	Systemp+ Xeno V^+	12.31±1.13
Group-VI	Systemp+ Futurabond DC	15.15±0.79

Table-2: Comparison of mean shear bond strength (MPa) values between Group I and Group IV

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)	P value
Group-I	Prime and Bond NT	15.07±0.31	0.04
Group-IV	Systemp +Prime and Bond NT	16.28±2.63*	

(*P<0.05)-significant when compared Group-I with Group-IV

Table-3:Comparison of mean shear bond strength (MPa) values between Group II and Group V

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)	P value
Group-II	Xeno V^+	14.47±1.31	0.05
Group-V	Systemp+ Xeno V^+	12.31±1.13*	

(*P<0.05)- significant when compared Group-II with Group-V

Table-4: Comparison of mean shear bond strength (MPa) values between the Group III and Group VI

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)	P value
Group-III	Futurabond DC	15.47±2.43	0.06
Group-VI	Systemp+Futurabond DC	15.15±0.79	

(P>0.05)- not significant when compared group-III with group-VI

Table-5: Comparison of mean shear bond strength (MPa) values Group-I with Group II and Group III

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-I	15.07±0.31	
Group-II	14.47±1.31*	0.05
Group-III	15.47±2.43	0.99

(*P<0.05)- significant when compared Group-I with Group II and Group III

Table-6: Comparison of mean shear bond strength (MPa) values Group-II with Group I and Group III

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-II	14.47±1.31	
Group-I	15.07±0.31*	0.05
Group-III	15.47±2.43*	0.05

(*P<0.05)- significant when compared group-II with Group I and Group III

Table-7:Comparison of mean shear bond strength (MPa) values Group-III with Group I and Group II

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-III	15.47±2.43	
Group-I	15.07±0.31	0.99
Group-II	14.47±1.31*	0.05

(*P<0.05)- significant when compared Group-III with Group I and Group II

Table-8: Multiple comparison of mean shear bond strength (MPa) values between the control groups

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)
Group-I	Prime and Bond NT	15.07±0.31
Group-II	Xeno V^+	14.47±1.31*
Group-III	Futurabond DC	$15.47 \pm 2.43^{\#}$

(*P<0.05)-significant when compared Group-I with Group II and Group III,($^{\#}$P<0.05)- significant when compared Group-II with Group I and Group III.

Table-9: Comparison of mean shear bond strength (MPa) value of Group-IV with Group V and Group VI,

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-IV	16.28±2.63	
Group-V	12.31±1.13*	0.03
Group-VI	15.15±0.79*	0.05

(*P<0.05)-significant when compared Group-IV with Group V and Group VI.

Table-10: Comparison of mean shear bond strength (MPa) value of group-V with Group IV and Group VI.

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-V	12.31±1.13	
Group-IV	16.28±2.63*	0.03
Group-VI	15.15±0.79*	0.04

(*P<0.05)- significant when compared group-V with Group IV and Group VI,

Table-11: Comparison of mean shear bond strength (MPa) value of Group-VI with Group IV and Group V

Groups	Shear Bond Strength (MEAN±SD)	P value
Group-VI	15.15±0.79	
Group-IV	16.28±2.63*	0.05
Group-V	12.31±1.13*	0.04

(*P<0.05)- significant when compared group-VI with Group IV and Group V.

Table-12: Multiple comparison of mean shear bond strength (MPa) values between the experiment groups

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)
Group-IV	Systemp+ Prime and Bond NT	16.28±2.63
Group-V	Systemp+ Xeno V^+	12.31±1.13*
Group-VI	Systemp+ Futurabond DC	15.15±0.79*,#

(*P<0.05)-significant when compared Group-IV with Group V and Group VI, (#P<0.05)- significant when compared Group-V with Group IV and Group VI.

Table-13: Multiple comparison of mean shear bond strength (MPa) values between the groups

Groups	Type of adhesive system	Shear Bond Strength (MEAN±SD)
Group-I	Prime and Bond NT	15.07±0.31
Group-II	Xeno V+	14.47±1.31*
Group-III	Futurabond DC	15.47±2.43#
Group-IV	Systemp+ Prime and Bond NT	16.28±2.63*,#,$
Group-V	Systemp +Xeno V+	12.31±1.13*,#,$,‖
Group-VI	Systemp+ Futurabond DC	15.15±0.79#,‖,⌉

*P<0.05,is significant when Group-I is compared with other groups, #P<0.05 , is significant when Group-II is compared with other groups, $P<0.05, is significant when Group-III is compared with other groups, ‖P<0.05, is significant when Group-IV is compared with other groups, P<0.05 , is significant when Group-V is compared with other groups

FIGURES

Figure 1 : Armamentarium

Figure 2 : Sixty freshly extracted maxillary premolars

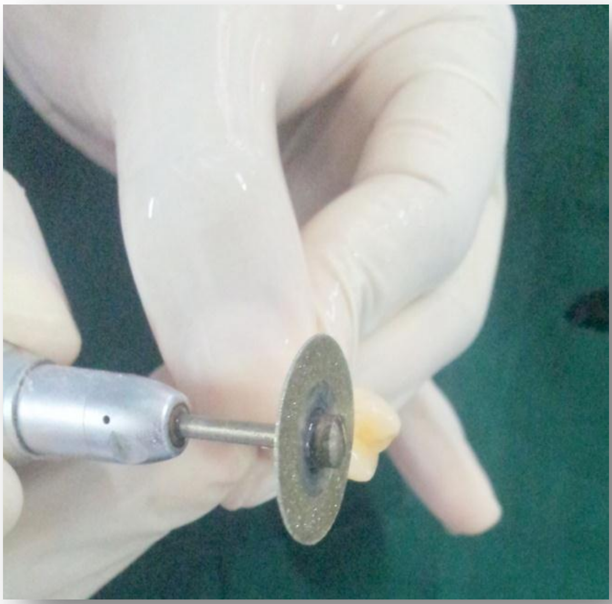

Figure 3: Sectioning of enamel to expose dentin.

Figure 4: Exposed dentine surface.

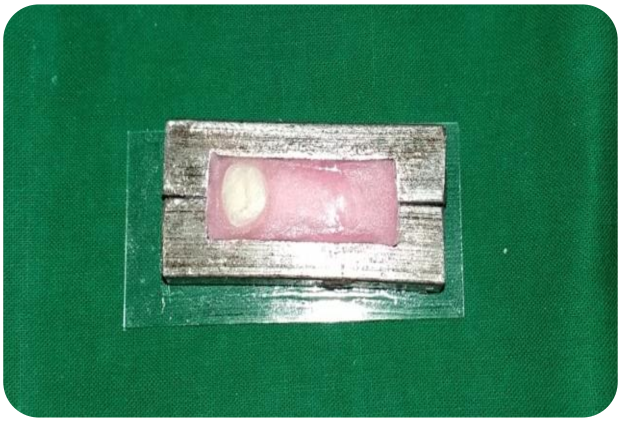

Figure 5: Tooth mounted in acrylic block.

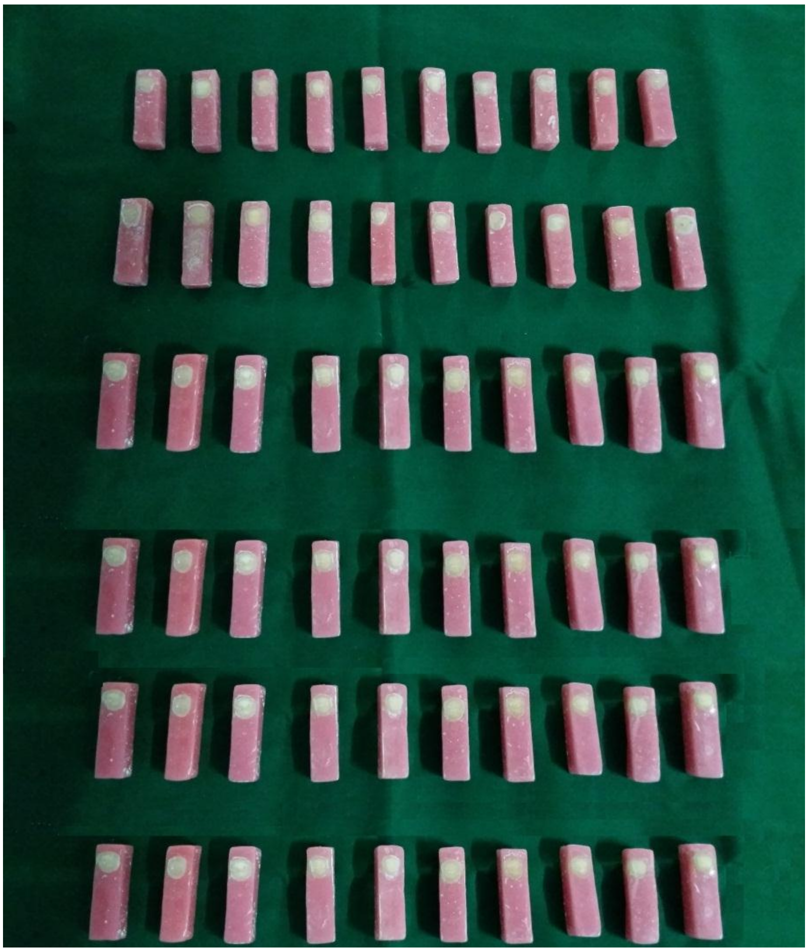

Figure 6: Sixty teeth embedded in acrylic blocks

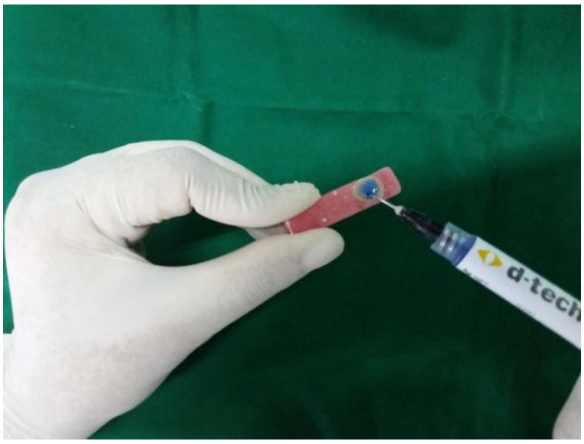

Figure 7: Etching of specimens

GROUP I

Figure 8(a) : Prime and Bond NT

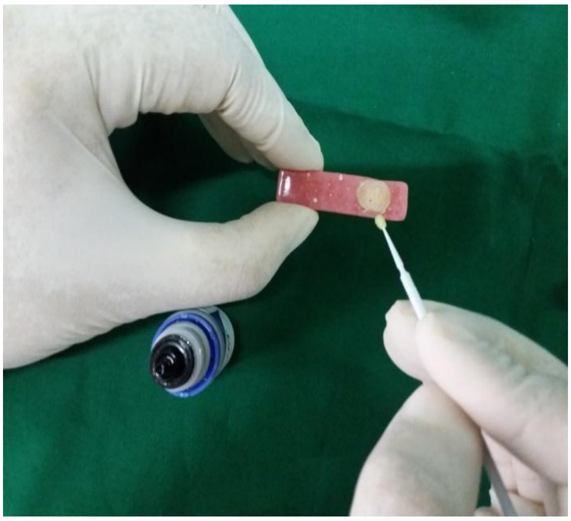

Figure 8(b): Application of bonding agent - Group I

GROUP II

Figure 9(a):Xeno V^+

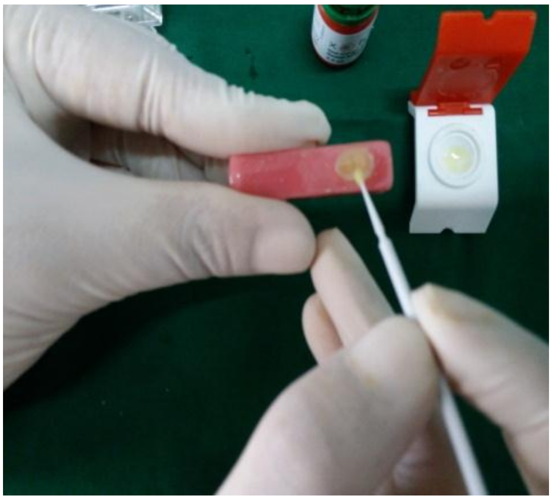

Figure 9(b): Application of bonding agent - Group II

GROUP III

Figure 10(a):Futurabond DC

Figure 10(b):Application of bonding agent - Group III

GROUP IV

Figure 11(a):Systemp

Figure 11(b):Application of dentin desensitizer

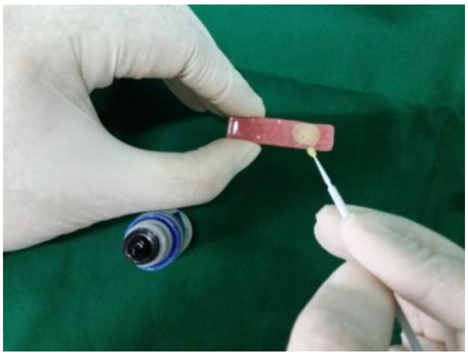

Figure11(c):Application of bonding agent - Group IV

GROUP V

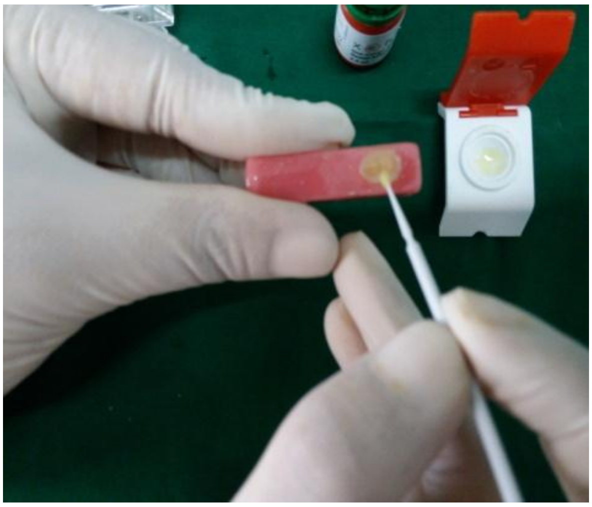

Figure 12(a): Application of dentin desensitizer

Figure 12(b) :Application of bonding agent-Group V

GROUP VI

Figure 13(a) : Application of dentin desensitizer

Figure 13(b) : Application of bonding agent – Group VI

Figure 14(a) : Stainless steel mould for composite

Figure 14(b) :Incremental placement of composite

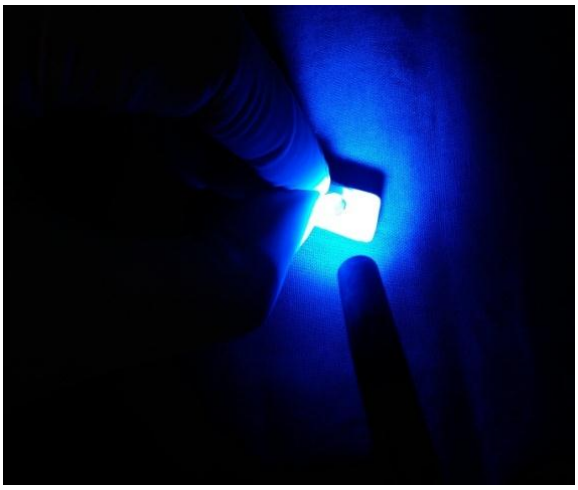

Figure 14(c) : Light curing of composite

Figure 14(d) :Specimen with composite

Figure 15 : Instron (Model 3345) universal testing machine with mounted specimen

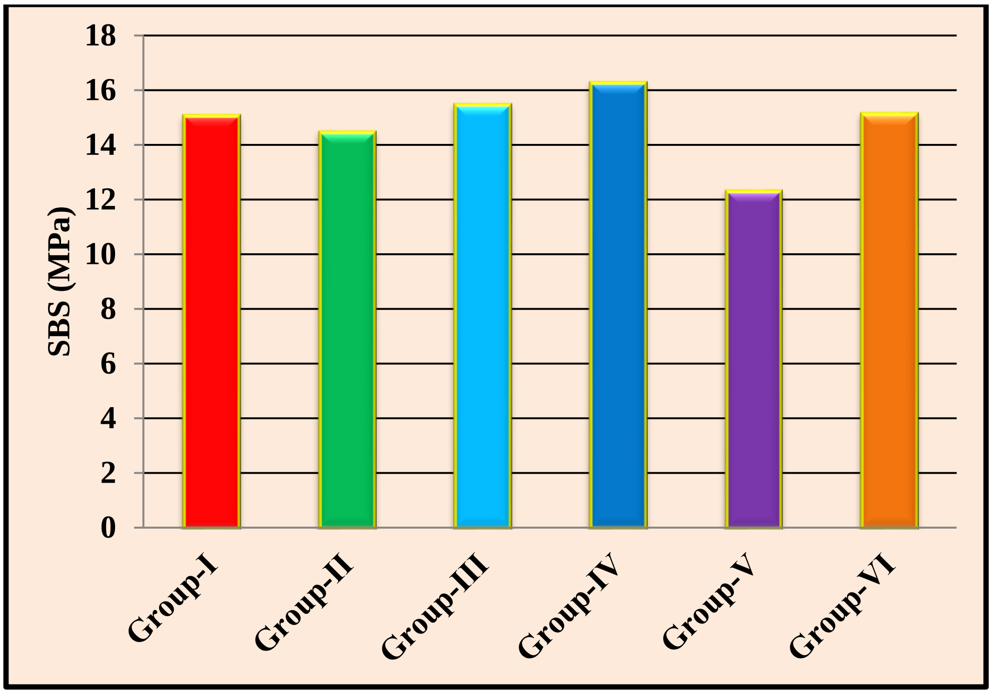

Figure-16: Graphical representation of mean shear bond strength (MPa) values of different adhesive systems in various groups

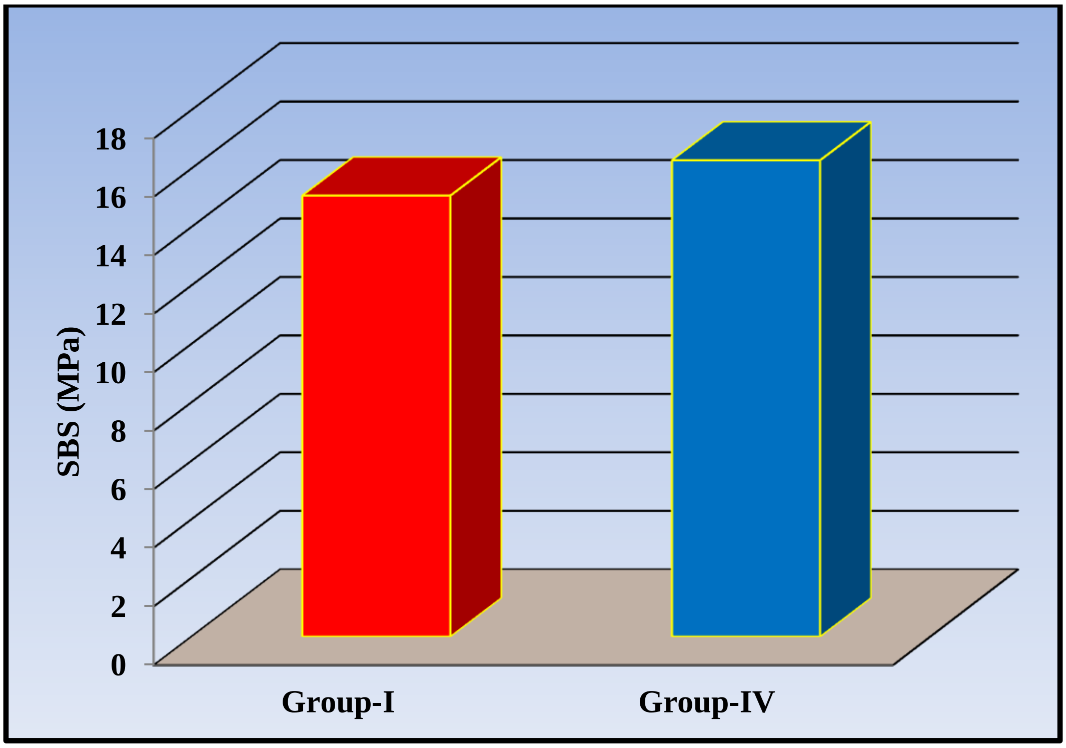

Figure 17: Graphical representation of comparison of mean shear bond strength (MPa) values between Group I and Group IV.

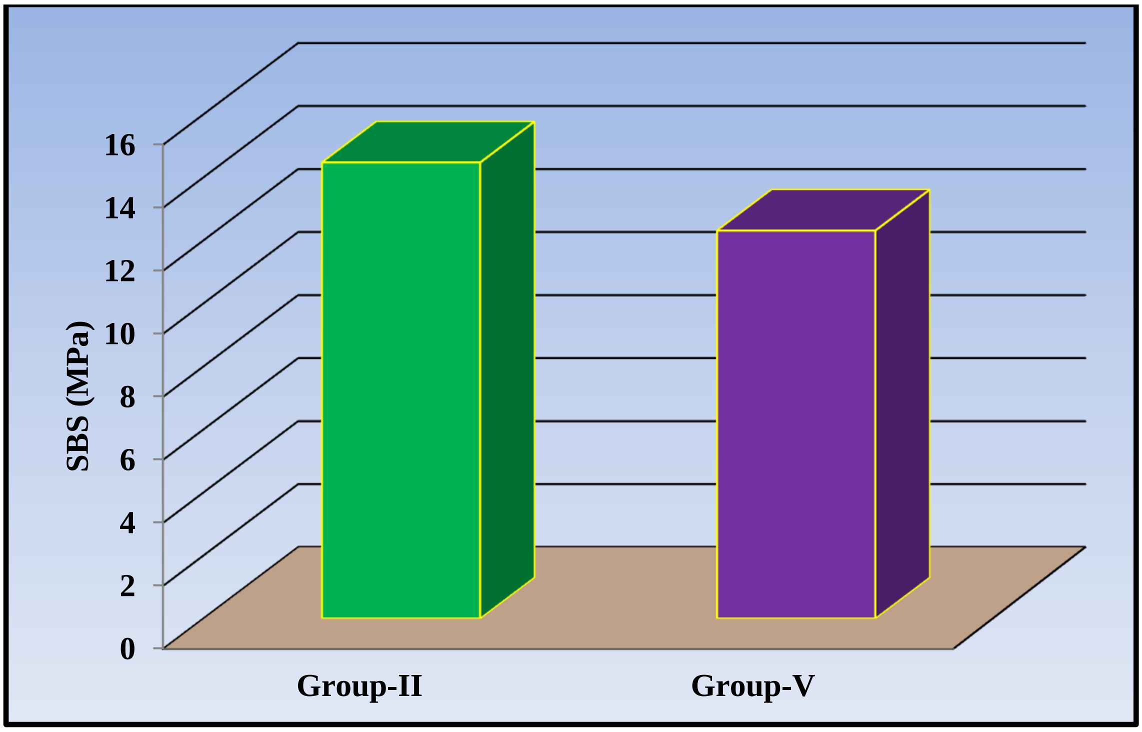

Figure 18: Graphical representation of comparison of mean shear bond strength (MPa) values between Group II and Group V.

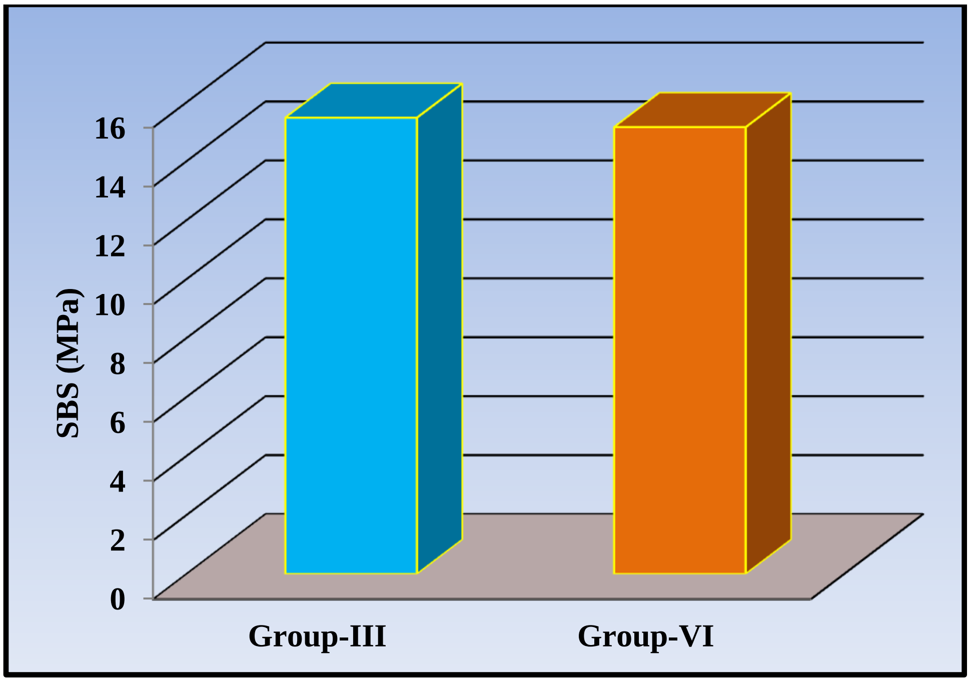

Figure 19: Graphical representation of comparison of mean shear bond strength (MPa) values between Group III and Group VI.

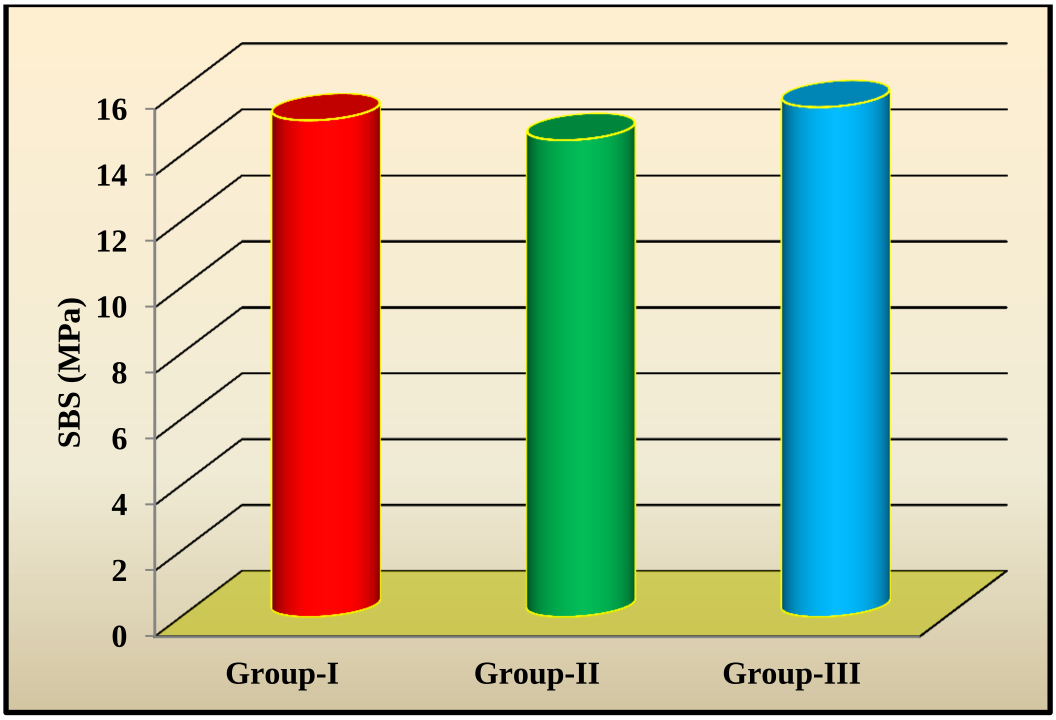

Figure 20: Graphical representation of multiple comparison of mean shear bond strength (MPa) values between Groups I , II and III.

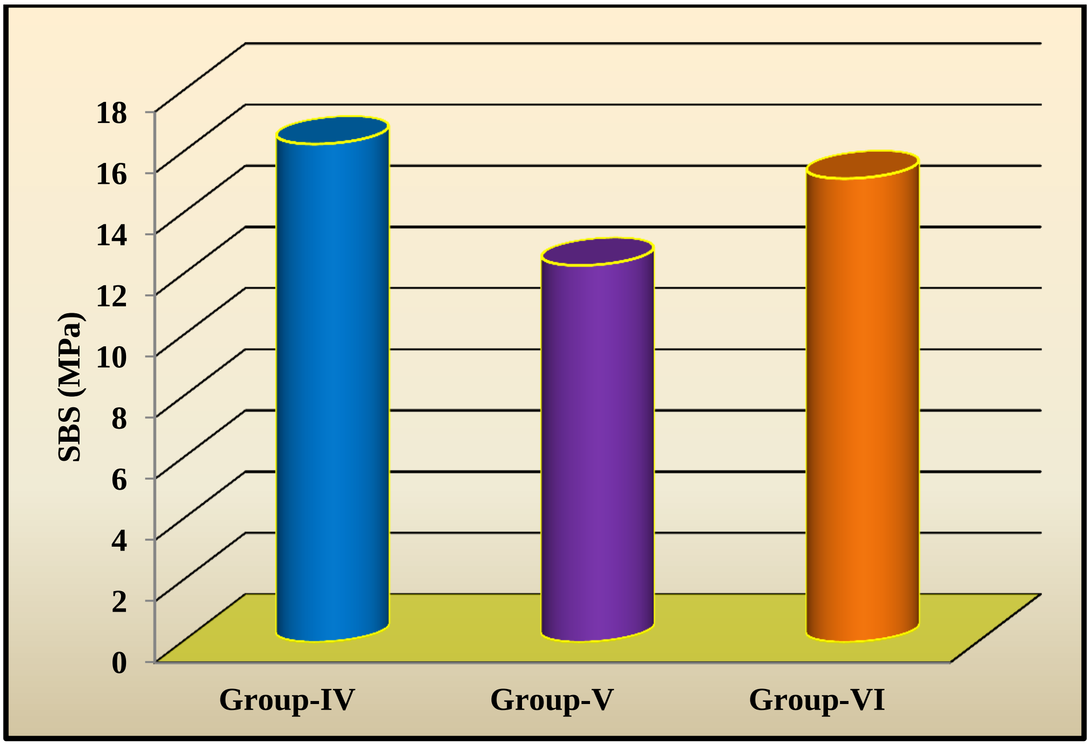

Figure 21: Graphical representation of multiple comparison of mean shear bond strength (MPa) values between Groups IV, V and VI.

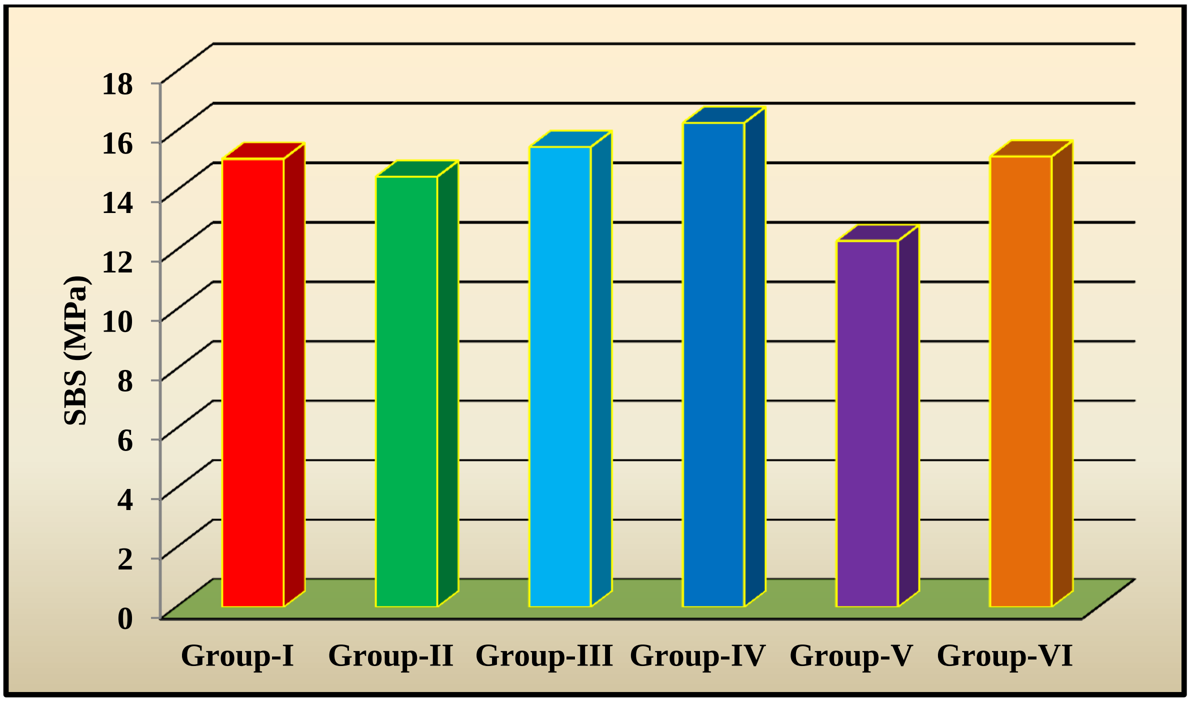

Figure 22: Graphical representation of multiple comparison of mean shear bond strength (MPa) values between different groups.

BIBLIOGRAPHY

1. Hassan AM, Goda AA, Baroudi K.The effect of different disinfecting agents on bond strength of resin composites. Int J Dent 2014;1-7.
2. Ravikumar N, Shankar P, Indira R. Shear bond strength of two dentin bonding agents with two desensitisers : An *in vitro* study. J Conserv Dent 2011;14(3):247-51.
3. Auschill TM, Koch CA, Wolkewitz M, Hellwig E, Arweiler NB. Occurrence and causing stimuli of postoperative sensitivity in composite restorations. Oper Dent 2009;34:3‑10.
4. Gordan VV, Mjor IA. Short and long term clinical evaluation of Post operative sensitivity of a new resin based restorative material and self etching primer. Oper Dent 2002;27:543‑48.
5. Unemori M, Matsuya Y, Akashi A, Oto YG, Akamine. Composite resin restoration and Postoperative sensitivity: Clinical follow–up in an undergraduate program. J Dent 2001;29:7‑13.
6. Akpata ES, Behbehani J. Effect of bonding systems on postoperative sensitivity from posterior composites. Am J Dent 2006;19:151‑54.
7. Nicola X. The dentine hypersensitivity patient – a total management package .Int Dent J 2007: 57:411-19.
8. Pashley DH. Dentine permeability and its role in the pathobiology of dentin hypersensitivity. Arch Oral Biol 1994;39:73-80.
9. Kulunk S, Sarac D, Kulunk T,Karakas O.J .The effects of different desensitizing agents on the shear bond strength of adhesive resin cement to dentin. Esthet Restor Dent 2011;23:380–89.

10. Nair M, Paul J, Kumar S, Chakravarthy Y, Krishna V, Shivaprasad. Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An *in vitro* study. J Conserv Dent 2014;17:27-30.

11. Stewardson DA, Crisp RJ, Creanor S, Lendenmann U, Burke FJ. The effectiveness of Systemp desensitizer in the treatment of dentin hypersensitivity. Prim Dent J 2004;11(3):71-6.

12. Joseph P, Yadav C, Kumar S, Raju R.Comparative evaluation of the bonding efficacy of sixth, seventh and eighth generation bonding agents : An *in vitro* study. Int J Pharm 2013;4(9):143-47.

13. Gangurde LB, Pawar MG, Shenoy VU, Margasahayam SV.A comparative evaluation of the shear bond strength of three different fifth generation dentin bonding agents: An *in vitro* study. J Contemp Dent 2014;4(1):1-5.

14. Toledano M, Osorio R, Leonardi G, Rosales-Leal JI, Ceballos L, Cabrerizo-Vilchez MA. Influence of self-etching primer on the resin adhesion to enamel and dentin. Am J Dent 2001;14:205-10.

15. Tay FR, Sano H, Carvalho R, Pashley EL, Pashley DH. An ultrastructural study of the influence of acidity of self-etching primers and smear layer thickness on bonding to intact dentin. J Adhes Dent 2000;2:83-98.

16. Carvalho RM, Chersoni S, Frankenberger R, Pashley DH, Prati C, Tay FR. A challenge to the conventional wisdom that simultaneous etching and resin infiltration always occurs in self-etch adhesives. Biomater 2005;26:1035-42.

17. Dentsply.Xeno V.Scientific Compendium 2009.Available from http://www.dentsply.de/bausteine.net/file/showfile.aspx?downdaid=8852&sp=E&domid=1042&fd=2.[Last cited on 2014 Aug 03].

18. Branstrom M. Sensitivity of dentine. Oral Surg Oral Med Oral Pathol 1966;21:517–26.

19. Felton DA, Bergenholtz G, Kanoy B .Evaluation of the desensitizing effect of gluma dentin bond on teeth prepared for complete-coverage restorations. Int J Prosthodont 1991;4:292-98.

20. Kerns DG, Scheidt MJ, Pashley DH, Horner JA, Strong SL, Van Dyke TE. Dentinal tubule occlusion and root hypersensitivity. J Periodontol 1991;62:421-28.

21. Reinhardt JW, Stephens NH, Fortin D .Effect of Gluma desensitization on dentin bond strength .Amer J Dent 1995;8:170-72.

22. Maciel KT, Carvalho RM, Ringle RD. The effect of acetone, ethanol, HEMA and air on the stiffness of human decalcified dentin matrix. J Dent Res 1996; 75:1851–58.

23. Tay FR, Gwinnett AJ. Micromorphological spectrum from over drying to over wetting acid conditioned dentin in water free, acetone based, single bottle primer/adhesives. Dent Mater 1996;12:236-44.

24. Jain P, Vargas MA, Denehy GE, Boyer DA. Dentin desensitizing agents: SEM and x-ray microanalysis assessment. Amer J Dent 1997;10:21-7.

25. Schupbach P, Lutz F, Finger WJ. Closing of dentinal tubules by gluma desensitizer.Eur J Oral Sci 1997;105(5):414-21.

26. Perdigao J, Swift JR, Heymann HO, Malek MA. Effect of a re-wetting agent on the performance of acetone-based dentin adhesives. Amer J Dent 1998;11:207-13.

27. Perdigao J, Meerbeek VB, Lopes MM, Ambrose WW. The effect of a re-wetting agent on dentin bonding. Dent Mater 1999;15:282-95.

28. Cardoso PE, Braga RR, Carrilho MR. Evaluation of micro–tensile, shear and tensile tests determining the bond strength of three adhesive systems. Dent Mater 1998;14:394-98.

29. Gillam DG, Khan N, Mordam NJ , Barber PM. SEM investigation of selected desensitizing agents in the dentin disc model. Endo Dent Traumatol 1999;15:198-204.

30. Ritter AV, Swift JR, Heymann HO, Perdigso J, Rosa BT. Effects of different re-wetting techniques on dentin shear bond strengths. J Esthet Dent 2000;12:85-96.

31. Jacobson PL, Bruce G. Clinical dentine hypersensitivity: understanding the causes and prescribing a treatment. J Contemp Dent Pract 2001;2(1):1-12.

32. Soeno K, Taira Y, Matsumura M, Atsuta M. Effect of desensitizers on bond strength of adhesive luting agents to dentin. J Oral Rehabil 2001;28(12):1122-28.

33. Bouillaguet S, Gysi P, Wataha JC, Ciucchi B, Cattani M, Godin C *et al.* Bond strength of composite to dentin using conventional, one-step, and self-etching adhesive systems. J Dent 2001;29(1):55-61.

34. Perdigão J, Geraldeli S, Carmo AR, Dutra HR. *In vivo* influence of residual moisture on microtensile bond strengths of one-bottle adhesives. J Esthet Restor Dent 2002;14:31–8.

35. Kolker JL, Vargas MA, Armstrong SR, Dawson DV. Effect of desensitizing agents on dentin permeability and dentin tubule occlusion. J Adhes Dent 2002;4(3):211-21.

36. Seara SF, Erthal BS, Ribeiro M, Kroll L ,Pereira. The influence of a dentin desensitizer on the micro tensile bond strength of two bonding system. Oper Dent 2002;27:154-60.

37. Tay FR, Pashley DH. Have dentin adhesives become too hydrophilic? J Can Dent Assoc 2003;69(11):726–31.

38. Qahtani MQ, Platt JA, Moore BK, Cochran MA. The effect on shear bond strength of rewetting dry dentin with two desensitizers. Oper Dent 2003;28(3):287-96.

39. Calneto , Miranda MS, Dias KR. Comparative SEM evaluation of penetration of adhesive systems in human dentin with anon-rinse conditioner and a self-etching primer. Braz Dent J 2004;15(1):19-25.

40. Ernst CP. Positioning self-etching adhesives: versus or in addition to phosphoric acid etching? J Esthet Restor Dent 2004;16(1):57-69.

41. Huang MS, Li MT, Huang FM, Ding SJ. The effect of thermocycling and dentine pre-treatment on the durability of the bond between composite resin and dentin.J Oral Rehab 2004;31:492–99.

42. Lührs AK, Guhr S, Schilke R, Borchers L, Geurtsen W, Günay H. Shear bond strength of self-etch adhesives to enamel with additional phosphoric acid etching. Oper Dent 2008;33(2):155-62.

43. Erhardt MC, Cavalcante LM, Pimenta LA. Influence of phosphoric acid pretreatment on self-etching bond strengths. J Esthet Restor Dent 2004;16:33-41.

44. Ritter AV, Heymann HO, Edward J,Swift JR. Effect of different rewetting techniques on dentin shear bond strength . J Esthet Restor Dent 2004;12:85-96.

45. Arrais CA, Chan DC, Giannini M. Effects of desensitizing agents on dentinal tubule occlusion. J Appl Oral Sci 2004;12(2):144-48.

46. Atash R, Abbeele AD. Bond strengths of eight contemporary adhesives to enamel and to dentine: an *in vitro* study on bovine primary teeth. Int J Paed Dent 2005;15:264–73.

47. Lehmann N, Degrange M. Effect of four dentin desensitizer on the shear bond strength of three bonding systems. Eur Cell Mater 2005;9:52–3.

48. Satoa M, Miyazakib M .Comparison of depth of dentin etching and resin infiltration with single-step adhesive systems. J Dent 2005;33:475–84.

49. Yiu CK, King NM, Suh BI, Sharp LJ, Carvalho RM, Pashley DH *et al.* Incompatibility of oxalate desensitizer with acidic fluoride containing total etch adhesives. J Dent Research 2005;84(8):730-35.

50. Soares CJ, Filho PC, Barreto BC, Mota AS .Effect of previous desensitizer and rewetting agent application on shear bond strength of bonding systems to dentin. Cienc Odontol Bras 2006;9(4):6-11.

51. Maurin JC, Lagneau C, Durand M, Lissac M. Tensile and shear bond strength of a total etch three - step and two self-etching one- step dentin bonding systems. J Adhes Dent 2006;8:27-30.

52. Qin C,Xu J, Zhang Y. Tubular structure and dentin hypersensitivity spectroscopic investigation of the function of aqueous 2 hydroxyethyl methacrylate/glutaraldehyde solution as a dentin desensitizer. Europ J Oral Sci 2006;114:354–59.

53. Awang RA, Masudi SM, MohdNor WZ. Effect of desensitizing agent on shear bond strength of an adhesive system. Arch Orofac Sci 2007;2:32–5.

54. Duran I, Sengun A. The long-term effectiveness of five current desensitizing products on cervical dentine sensitivity. J Oral Rehabil 2004;31:351-56.

55. Aranha AC, Siquerira JR, Cavalcante LM , Pimenta LA, Marchi GM. Microtensile bond strengths composite to dentin treated with desensitizer products. *Quintessence* Int 2006;8:85-90.

56. Souza FC , Marco FF, Casemira LA, Panzeri H. Desensitizing bioactive agents improves bond strength of indirect resin – cemented restoration. J Appl Oral Sci 2007;15:120-26.

57. Bradna P, Vrbova R, Dudek M, Roubickova A ,Housova D. To estimate the *in vitro* reliability of typical self-etching and etch-and-rinse adhesives of various application protocols. J Adhes Dent 2008;10(6):423-29.

58. Hegde MN, Bhandary S. An evaluation and comparison of shear bond strength of composite resin to dentin, using newer dentin bonding agents. J Conserv Dent 2008;11(2):71-5.

59. Huh J, Kim J, Chung M , Lee H, Choi YG ,Shim JS. The effect of several dentin desensitizers on shear bond strength of adhesive resin luting cement using self-etching primer. J Dent 2008;36:1025–32.

60. Dundar M, Cal E, Gokce B, Turkun M, Ozcan M. Influence of fluoride or triclosan based desensitizing agents on adhesion of resin cements to dentin. Clin Oral Invest 2010;14:579-86.

61. Omae M. Effect of a desensitizing agent containing gluteraldehyde and HEMA on bond strength to ER:YAG laser-irradiated dentine. J Dent 2007;35:398- 402.

62. Dhawan R, Indira R, Dhawan S. A comparative evaluation of tensile bond strength and hybrid layer of three generation bonding agents by scanning

electron microscope-an *in vitro* study .J Oral Health Comm Dent 2008;2(2):36-41.

63. Ammar AA, Drummond JL, Russo AK .Effects on bonding to tooth structure treated with glutaraldehyde/HEMA the use of collagen cross-linking agents to enhance dentin bond strength. J Biomed Researc 2009;91:419-24.

64. Niazy MA, Jamil WE. The role of adhesive systems and dentin desensitizers in altering the permeability of human dentin. Cairo Dent J 2009;25(3):433-42.

65. Sevimay M, OzyesilAg ,Uludamar A. Microtensile bond strengths of composite to dentin treated with different desensitizers. Su DishekFak Derg 2009;18:154-60.

66. Yaseen SM, Subba Reddy VV .Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth: An *in vitro* study. Ind Soc Pedod Prev Dent 2009;27(1):33-8.

67. Cristina SS, Marcia PT, Denise PS, Gibson WL, Santos FA. *In vitro* and *in vivo* analysis of the effects of desensitizing agents on dentin permeability and dentinal tubule occlusion. J Oral Sci 2010;52(1),23-32.

68. Sailer I, Tettamanti S, Stawarczyk B , Fischer J, Hammerle HP. *In vitro* study of the influence of dentin desensitizing and sealing on the shear bond strength of two universal resin cements. J Adhes Dent 2010;12:381-92.

69. Ishihata H. Effects of gluteraldehyde, HEMA and gluma desensitizer on *in vitro* dentin permeability. Int J Contemp Dent 2011;2(1):3-8.

70. Ravikumar N, Shankar P, Indira R. Shear bond strengths of two dentin bonding agents with two desensitizers: An *in vitro* Study. J Conserv Dent 2011;14:247-51.

71. Veerakumar, Prabhu MN, Vijayaragavan, Pari A. A comparative evaluation of interfacial morphology of two adhesive systems in primary and permanent teeth- a SEM evaluation. Ind J Multidiscip Dent 2011;1(6):321-24.

72. Bhatia S, Krishnaswamy MM. Effect of two different dentin desensitizers on shear bond strength of two different bonding agents to dentin: an *in vitro* study. Ind J Dent Res 2012;23:703-8.

73. Adebayo OA, Burrow MF, Tyas MJ. Relationship between composite fracture toughness and bond strengths to enamel and dentin. Aust Dent J 2012;57:319–24.

74. Pei D**,** Liu S, Huang C, Du X, Yang H, Wang Y, *et al*. Effect of pretreatment with calcium-containing desensitizer on the dentine bonding of mild self-etch adhesives. Eur J Oral Sci 2013;121:204–10.

75. Ding M, Shin S, Kim M, Ryu J, Lee J. The effect of a desensitizer and CO_2 laser irradiation on bond performance between eroded dentin and resin composite. J Adv Prosthodont 2014;6:165-70.

76. Sancakli HS, Yildiz E, Bayrak I, Ozel S. Effect of different adhesive strategies on the post-operative sensitivity of class I composite restorations. Eur J Dent 2014;8:15-22.

77. Jose P, Sakhamuri S, Sampath V, Sanjeev K, Sekar M. Degree of conversion of two dentin bonding agents with and without a desensitizing agent using fourier transform infrared spectroscopy: An *in vitro* Study. J Conserv Dent 2011;14:302-5.

78. Porto IC.Post operative sensitivity in direct composite restorations: Clinical Practice Guidelines.Ind J Rest Dent 2012;1:1-12.

79. Cavalcanti AN, Souza ES, Lopes GS, Freitas AP, Araújo AP, Mathias P. Effect of a desensitizing dentifrice on the bond strength of different adhesive systems. Braz J Oral Sci 2013;12(2):148-52.

80. Andreatti LS, Lopes MB, Guiraldo RD, Borges AH, Dorilêo MC, Gonini JA. Effect of desensitizing agents on the bond strength of dental adhesive systems. App Adhesion Sci 2014;2:24-5.

81. Makkar S, Goyal M, Kaushal A, Hegde V. Effect of desensitizing treatments on bond strength of resin composites to dentin- An *in vitro* study. J Conserv Dent 2014;17:458-61.

82. Margvelashvili M, Beloica M, Carvalho CA, Papacchini F, Cantoro A, Goracci C Bonding potential of all-in-one adhesives to ground enamel. Int Dent Sa 2014;11(1):64-9.

83. Casgrande L, Brayner R, Barata SJ, Araujo BF. Cervical microleakage in composite restorations of primary teeth – *in vitro* study. J Dent 2005;33;627-32.

84. Holland GR. Morphological features of dentin pulp related to dentin sensitivity. Arch Oral Biol 1944;39:3–11.

85. Akpata ES, Sadiq W.Post-operative sensitivity in glass-ionomer versus adhesive resin-lined posterior composites. Am J Dent 2001;14:34-8.

86. Perdigão J, Lopes M .Dentin bonding – state of the art. Compend Contin Educ Dent 1999;20:1151–58.

87. Addy M,Pearce N. Aetiological predisposing and environmental factors in hypersensitive dentine. Arch Oral Biol 1994;39:33-8.

88. Christensen GJ.Acceptability of alternatives for conservative restoration of posterior teeth. J Esthet Dent 1995;7:228–32.

89. Baratieri LN. Ritter AV, Perdigão J, Felipe LA. Direct posterior composite resin restorations: current concepts for the technique. Pract Periodont Aesthet Dent 1998;10:875-86.

90. Voco.Futurabond DC. Available from http://www.voco.com/us/product/futurabond_dc/Futurabond_scientific_product_information.pdf [Last cited on 2014 Jun 2014].

91. Kimochi T, Yoshiyama M, Urayama A, Matsuo T. Adhesion of new commercial self etching/self-priming bonding resin to human caries infected dentin. Dent Mater 1999;18(4):437-43.

92. Naughton W, Latta M. Bond strength of composite to dentin using selfetching adhesive systems. *Quintessence* Int 2005;36:259-62.

93. Silverstone LM.Fissure sealants: Laboratory studies. Caries Res 1974;8:2-26.

94. Zidam O, Hill G.Phosphoric acid concentration: Enamel surface loss and bonding strength. J Prosthet Dent 1986;55:388-92.

95. Legler LR, Retief DH, Bradley EL: Effects of phosphoric acid concentration and etch duration on enamel depth of etch: An *in vitro* study. Am J Orthod Dentofac Orthop 1990;98:154-60.

96. Meerbeeck VB, Inokoshi S, Braem M, Lambrechts P, Vanherle G: Morphological aspects of the resin-dentin interdiffusion zone with different dentin adhesive systems. J Dent Res 1992; 71:1530-40.

97. Chow LC, Brown WE: Phosphoric and conditioning of teeth of pit and fissures sealants. J Dent Res 1973;52:1158.

98. Gottlieb EW, Retief DH, Jamison HC: An optimal concentration of phosphoric acid as an etching agent. Part I: Tensile bond strength studies. J Prosthet Dent 1982;48:48-51.

99. Barkmeier WW, Shaffer SE, Gwinnett AJ: Effects of 15 vs 60 second enamel acid conditioning on adhesion and morphology. Oper Dent1986;11:111-16.

100. Gwinnett AJ, Kanca J: Micromorphological relationship between resin and dentin *in vivo* and *in vitro*. Am J Dent 1992;5:19-23.

101. Miyazaki, Sato MH , Onose H , Moore BK , Platt JA . Analysis of the dentin/adhesive resin interface with laser Raman microscopy. Oper Dent 2003;28(2):136-42.

102. Hashimoto M, Ohno H ,Yoshida E, Hori M, Sano H, Kaga M,*et al*. Resin-enamel bonds made with self-etching primers on ground enamel. Eur J Oral Sci 2003;111(5):447–53.

103. Landuyt VK, Kanumilli P, De Munck J, Peumans M, Lambrechts P, Meerbeek VB .Bond strength of a mild self-etch adhesive with and without prior acid-etching. J Dent 2006;34:77-85.

104. Chaves P, Giannini M, Ambrosano GM. Influence of smear layer pretreatments on bond strength to dentin. J Adhes Dent 2002;4:191-96.

105. Ikeda M, Kurokawa H, Sunada N, Tamura Y, Takimoto M, Murayama R, *et al*. Influence of previous acid etching on dentin bond strength of self-etch adhesives. J Oral Sci 2009;51:527-34.

106. Pashley DH, Carvalho RM.Dentine permeability and dentine adhesion. J Dent 1997;25:355- 72.

107. Perdigão J, Lambrechts P, Meerbeek VB, Tomé AR, Vanherle G, Lopes AB. Morphological field emission-SEM study of the effect of six phosphoric acid etching agents on human dentin. Dent Mater 1996;12:262-71.

108. Frankenberger R, Lohbauer U, Roggendorf MJ, Naumann M, Taschner M. Selective enamel etching reconsidered: better than etch-and-rinse and self-etch? J Adhes Dent 2008;10:339-44.

109. Landuyt VK, Snauwaert J, Munck J, Peumans M, Yoshida Y, Poitevin A. systematic review of the chemical composition of contemporary dental adhesives. Biomaterials 2007;28(26):3757-85.

110. Sabatini C. Effect of phosphoric acid etching on the shear bond strength of two self-etch adhesives. J Appl Oral Sci 2013;21(1):56-62.

111. Dijkman GEHM, Jongebloed WL, de Vries J, Ögaard B, Arends J . Closing of dentinal tubules by gluteraldehyde treatment, a scanning electron microscopy study. Scand J Dent Res 1994;102:144-50.

112. Arora S , Yadav S, Yadav H,Sharma S. A comparative evaluation of shear bond strengths of composite to dentin, using total etch and self etch dentin bonding agents - an *in vitro* study . Ind J Dent Sci 2015;7(2):31-6.

113. Voco.Futurabond DC. Available from http://www.voco.com/us/product/futurabond_dc/Futurabond_scientific_product_information.pdf [Last cited on 2014 Jun 2014].

114. Eick JD, Welch FH. Dentin adhesives - do they protect the dentin from acid etching *Quintessence* Int 1986;17(9):533-44.

115. Tay FR, Gwinnett AJ, Pang KM, Wei SH. Resin permeation into acid-conditioned, moist, and dry dentin: a paradigm using water-free adhesive primers. J Dent Res 1996;75:1034-44.

116. Reinhardt JW,Stephens NH, Fortin D. Effect of Gluma desensitization of dentin bond strength. Am J Dent 1995;8:170-72.

117. Cobb DS, Reinhardt JW, Vargas MA. Effect of HEMA-containing dentin desensitizers on shear bond strengths of a resin cement. Am J Dent 1997;10(2):62-5.

118. Ritter AV, Swift EJ, Yamauchi M. Effects of phosphoric acid and glutaraldehyde-HEMA on dentin collagen. Eur J Oral Sci 2001;109(5):348-53.

119. Tam LE, Pilliar RM. Fracture surface characterization of dentin-bonded interfacial fracture toughness specimens. J Dent Res 1994;73:607-19.

120. Kato G, Nakabayashi N. The durability of adhesion to phosphoric-acid etched, wet dentin substrates. Dent Mater 1998;14:347-52.

121. Sugizaki J. The effect of various primers on the dentin adhesion of resin composites. SEM and TEM observations of the impregnated layer and adhesion promoting effect of the primers. J Conserv Dent 1991; 34:228-65.

122. Tay FR, Gwinnett AJ, Wei SH. Relation between water content in acetone-alcohol based primer and interfacial ultrastructure. J Dent 1998;26:147-56.

123. Bansal A , Shivanna V. Effect of rewetting agents on the shear bond strength of different bonding agents when applied on dry dentin. J Conserv Dent 2007;10:26-32.

124. Kerby RE, Knobloch LA, Clelland N, Lilley H, Seghi R. Microtensile bond strengths of one-step and self–etching adhesive systems. Oper Dent 2005;30(2):195-200.

125. Chuang S, Chang L, Chang C, Yaman P, Liu J.Influence of enamel wetness on Composite restorations using various dentin bonding agents; Part 2 – effects on shear bond strength. J Dent 2006;34:352-61.

126. Senawongse P, Sattabanasuk V, Shinada Y, Otsuki M, Tagami J.Bond strengths of current adhesive systems on intact and ground enamel. J Esthet Restor Dent 2004;16(2):107-16.

127. Lopes G, Baratieri L, Andrada C, Vieira C.Dental adhesion: present state of the art and future perspectives. *Quintessence Int* 2002;33:213-24.