A COMPARATIVE STUDY OF SHEAR BOND STRENGTH OF REPAIRED PORCELAIN FUSED METAL RESTORATIONS AND ITS INTERFACE ADAPTATION - AN INVITRO STUDY

Dissertation submitted to

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY

in the partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

PART II – BRANCH I

PROSTHODONTICS AND CROWN & BRIDGE

APRIL – 2011

CERTIFICATE

This is to certify that this dissertation titled **"A Comparative Study of shear bond strength of repaired porcelain fused metal restorations and its interface adaptation-An invitro study"** is a bonafide record of work done by **Dr.M.LAKSHMI DEVI** under my guidance during her postgraduate period between 2008- 2011. This Dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in Partial fulfilment of requirements for the Degree of **Master of Dental Surgery in Prosthodontics and Crown & Bridge (Branch I).**

It has not been submitted (partial or full) for the award of any other degree or diploma.

GUIDE & HEAD OF THE DEPARTMENT

Dr. C. THULASINGAM, M.D.S.
Professor & Head
Department of Prosthodontics
Tamilnadu Government Dental College & Hospital,
Chennai – 03

PRINCIPAL

Dr.K.S.G.A.NASSER, M.D.S.
TamilNadu Government Dental College & Hospital
Chennai – 600 003

DECLARATION

I, **Dr.M.Lakshmi Devi**, do hereby declare that the dissertation titled **"A Comparative Study of shear bond strength of repaired porcelain fused metal restorations and its interface adaptation- An invitro study"** was done in the Department of Prosthodontics, Tamil Nadu Government Dental College & Hospital, Chennai - 600 003. I have utilized the facilities provided in the Government Dental College for this study in partial fulfillment of the requirements for the degree of **Master of Dental Surgery** in the speciality of **Prosthodontics and Crown & Bridge (Branch I)** during the course period 2008-2011 under the conceptualization and guidance of my dissertation guide, **Dr. C. Thulasingam, M.D.S, Head of the Department.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare, that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work, and I firmly affirm that the right to preserve or publish this work rests solely with the permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG Student   Signature of the HOD

Signature of the Head of the Institution

INTRODUCTION

The smile is one of the most appealing aspects of the human face and is considered to be very image of the soul. An esthetically pleasing appearance of teeth is the best asset for a good smile. Esthetics is a demanding factor when the restoration in the missing anterior esthetic zone is considered and achieving balance between the functional stability and cosmetic appeal has been a major challenge to the dental professionals

Porcelain was successfully adapted for dental restorations by the end of the 1800s. Though earlier all porcelain crowns fulfilled the esthetic demand the inherent brittleness of these crowns, lack of marginal integrity, difficulty of cementation and questionable survival made them to meet the functional requirement which limit their use in dentistry [1]

Dr. Charles Land introduced one of the earliest forms of ceramic crowns in 1903. Then the first metal-ceramic crown was described by Brecker in1956.[2] Since then various types of metal ceramic restorations have been developed with advancements being made in both metal and porcelain for an effective metal ceramic bond. The development of porcelain fused metal restorations is an attempt to return the patient to as near normal function and appearance as possible.

From its introduction till date, the porcelain fused metal restorations have a long proven record of success because of their good compressive strength, marginal fit, esthetics, and versatility to be used for both single crown and fixed partial denture.

Though ceramic materials provide excellent restorative service over the years, but ceramic fracture does occur intraorally. Clinical studies indicate that the prevalence of ceramic fractures are ranged from 5 to 10% over years of use.[3] Fractures in Porcelain Fused Metal restorations may occur in two ways. 1. Fracture within the porcelain layer (cohesive failure). 2. Fracture of porcelain layer partly or completely separated from the metal substrate (Adhesive failure)[4].

Clinically, such fractures often begins as porcelain fractures that may be caused by inappropriate coping design, poor abutment preparation, technical errors, physical trauma, parafunctional habits, flexural failure of metal substructure, failures in adhesive bonding, incompatibility of the coefficient of thermal expansion between the porcelain and the metal structure, contamination, porosities in the porcelain.[5,6]

The fracture of Porcelain Fused Metal restorations is one of the common clinical situation occurs in routine clinical practice. Factors such as trauma to the tooth, lack of time, and difficulty in removing restorations may cause delay in the replacement of fractured metal ceramic restoration.[5] Repair may be indicated in such occasions. Repair of fractured metal ceramic restoration helps to reestablish the function and the esthetics of restoration by using various repair materials. The suitable repair material which is regularly used in repair of Porcelain Fused Metal restorations is composite resins[7].

The development of the composite restorative materials and introduction of organosilanes by Bowen in 1962 has made intraoral chair side repair of porcelain to achieve satisfactory result. Composite resins has become the material of choice for its mode of cost, excellent esthetics, reparability in mouth and ease of manipulation.[8,9]

The clinical success of ceramic repair is almost entirely dependent on the integrity of the bond between the ceramic-metal substrate and composite resin[10]. The development in the technology of adhesive systems has presented numerous bonding systems to overcome the problem of bonding composite to fractured ceramic restoration.

Studies have revealed that the bond strength of porcelain and metal substrate is affected by the type of composite material, surface preparation and the type of bonding agent.[3,11,12,13,14]

Intraoral repair of fractured porcelain relies on the survival of the repair material being used. The repair material should have minimal coefficient of thermal expansion and minimal polymerization shrinkage. Large particle composite resin or hybrid resins at ceramic interface results in higher bond than those of microfilled composites.[3,15]

Various methods have been tested and tried to repair a fractured Porcelain Fused Metal restorations among which repair with composite resins has given some fruitful results, but the poor bond strength of composite resin with the metal and ceramic materials have always been subject of concern.

Surface preparation of the fractured site is also a major concern which relies on the mechanical roughening of the fractured surface, followed by the application of Silane coupling agent to enhance the resin to porcelain bond.[3,11,12,13,14]

Various surface treatments like acid etching, air abrading and surface roughening with diamond abrasives have been recommended to improve the surface area for mechanical interlocking.[3,11,12,13,14] Mechanical roughening of the metal or ceramic with Aluminium oxide air abrasion has been described as the most effective surface treatment for fractured metal ceramic restoration.[12]

In the view of above considerations, the present study was conducted to evaluate and to compare the shear bond strength of the repaired porcelain fused metal restorations with different composite resins and the closer adaptation of composite and the ceramic at the fracture interface. The null hypothesis of this study was, there is no difference in the shear bond strength of different composite restorative materials to the porcelain fused metal restorations.

AIMS AND OBJECTIVES

AIM:

To evaluate the shear bond strength of repaired porcelain fused metal restorations by using different types of commercially available composite restorative materials.

OBJECTIVES OF THE STUDY:

1. To evaluate the shear bond strength of fractured ceramic using different commercially available composite resins keeping surface treatment of metal and ceramic standard.
2. To compare the shear bond strength of fractured ceramic using different commercially available composite resins keeping surface treatment of metal and ceramic standard.
3. To evaluate the bonding ability at the interface between composite resin and the metal.
4. To evaluate the bonding ability at the interface between composite resin and the ceramic.

REVIEW OF LITERATURE

Miller T.H. et al (1971)[16] demonstrated a technique of repairing fractured fixed partial dentures through the use of pin retainers without removing them from the mouth. By this technique fractured porcelain surfaces, and uncemented or carious abutments can be repaired or replaced without destroying the rest of the prosthesis.

Welsh SL et al (1977)[17] described a technique which can be employed to repair fractured porcelain - fused- to metal restorations using an overcasting. Author suggested that many expensive and time consuming remakes can be prevented by using this procedure.

Robert Dent J (1979)[18] suggested three techniques (1) Porcelain fused to metal overcasting (2) Porcelain fused to metal pin retained casting (3) Composite repair material to repair the fractured site also suggested fabrication of pin only, with an acrylic veneer cemented to the labial surface.

R.M.Highton et al (1979)[19] reported the effectiveness of two porcelain repair systems using coupling agent. One system bonds any acrylic resin to the fractured porcelain, other bonds specific composite resin. The repair system using acrylic resin is significantly stronger and proven to be best potential for clinical success in porcelain to porcelain repairs.

Thomas P. Noulin et al (1981)[9] studied bond strength before and after thermally induced stresses of three composite for repairing dental porcelain. Groups – Denmat bonding agent and repair material, fusion bonding agent with Concise and Ceramco dent bonding agent and Cervident used. The overall strength of repair material was low and indicated their use in temporary clinical procedures.

Jean Mark P. et al (1983)[20] compared five porcelain repair system and evaluated (1) Tensile strength (2) Microleakage at the interface of the material and porcelain (3) Possible relationship between Tensile strength microleakage. Products - adaptic, cyano-veneer, Denmat porcelain repair kit, Enamelite 500 and Fusion. Enamelite 500 was found superior because of highest tensile strength than other materials.

J. C. Meiers et al (1985)[21] Investigated three surface treatments (1) Abrasion , (2) Abrasion , Salivary contamination and air / water spray cleaning (3) Abrasion , Salivary contamination and cleaning with resin monomer. Neither abrasion nor abrasion with salivary contamination decreased the shear bond strengths of etched metal specimens bonded to bovine enamel.

Anthony H. L. Tjan et al (1987)[4] Suggested various factors contribute to the weakening of the bond (1) Reaction with water (2) Stresses developed at the interfaces between the materials (3) Stresses resulting from the difference in the coefficients of thermal expansion.

David G. Naegeli et al (1988)[22] Evaluated the shear bond strength of two composites to cast alloy using three adhesive bonding systems. Silicoater system with Dentacolor composite showed significantly higher bond strength than other five combinations.

Izchak Barzilay et al (1988)[5] Evaluated mechanical and chemical retention of laboratory light cured composites to base metal alloys using seven types of retention systems and concluded mechano chemical techniques with etched – 4 META and small bead silicoat material recorded elevated bond strengths. Chemical bonding minimized gap formation at the composite – metal interfaces.

Alton M. Lacy et al (1988)[13] Investigated six surface treatment of feldspathic porcelain on the shear strength of the bond developed between composite and treated porcelain. Silane coupling agents used in conjunction with acid – etching of porcelain surfaces may creates a bond stronger than cohesive strength of the porcelain.

J. I Nicholls (1988)[23] Determined the relative tensile bond strengths of five resin cements to etched porcelain. In addition the effect of (1) Two silane products, (2) The use of an unfilled resin as a wetting agent, (3) The effect of saliva contamination and its removal, and (4) A 7 – days delay in applying the cement to the etched porcelain were determined and concluded Scotch prime provided the superior bond strength than Porcelain repair.

J. H. Bailey (1989)[24] In this study the flexural strengths of porcelain bonded to composite resin specimens using four organosilane materials were compared. Three groups of hydrated specimens were repaired using Silux composite resin with kerr Ultrafine porcelain Repair Bonding system, 3M Porcelain Kit with Scotch Primer, Fusion materials and DenMat Ultra-bond Restorative kit. Four groups of unhydrated specimens were repaired the same as the hydrated specimens. And found, the DenMat product had lower strengths, the unhydrated specimens had significantly higher bond strength than the hydrated specimens.

M. Diaz-Arnold et al (1989)[25] Investigated shear bond strength of three porcelain repair system. Glazed and roughened porcelain surfaces were evaluated. Repair systems were Fusion, Scotchprime, and Ultra- Bond. And found the presence of porcelain autoglaze did not significantly affect the bond strength of Scotchprime material whereas it significantly decreased the bond strengths of the other system.

Daivd A. Beck et al (1990)[26]This study was designed to test the shear bond strength of composite resin to the metal substrate of porcelain fused- to-metal restorations and to compare it with the bond strength to the dental porcelain. All mean bond strengths of the composite resins to the oxidized or machined alloy were significantly lower than their bond strength to porcelain. The bond strength of machined alloy were consistently lower than those oxidized alloy.

Nico H.J. Creugers et al (1992)[27] Evaluated an experimental porcelain repair systems under astringent conditions in posterior teeth with regard to survival of the repairs and esthetic appearance. And found wear and surface deterioration is not related to the repair system but to the use of microfilled composite resin.

Ronald E. Appeldoorn et al (1993)[8] compared the mean shear bond strength of composite resin bonded to porcelain with eight newer generation repair system. (1) All bond 2 and Bis-Fil, (2) Cerinate Prime and ultra Bond,(3) Clearfil Porcelain Bond and clearfil Photo- Anterior, (4) Etch-Free and Bis-Fil, (5) Monobond-S and Heliomolar Radiopaque, (6) Porcelite and Hereulite XRV, (7) Scotchprime and Silux-Plus and (8) Silistor and Multifil VS. No significant difference existed between the 24-hour and 3 months values produced by the Clearfil porcelain Bond, Porcelite and Scotchprime repair system. The porcelain repair system that produced the greatest bond strengths generally produced the greatest number of cohesive failures in the porcelain, with the exception of the Etch-Free System.

Abdul-Haq A.Suliman et al(1993)[14] this study evaluated porcelain repair by use of various surface treatments, such as air abrasion(sandblasting with a diamond), etching with 9.6% hydrofluoric acid, and a combination of the latter two methods. And found the most effective surface treatment was the combination of diamond roughening and hydrofluoric acid etching, but it was not significantly better than the other methods.

John W. Thumond et al (1994)[24] conducted a study to evaluate the bond strength of composite resin bonded to porcelain surface by use of a variety of treatment regimens with All-Bond 2 adhesive system. They concluded that mechanical alteration of a porcelain surface is more important than agents that promote chemical bonding of composite resin to porcelain. Porcelain treatment with a combination of aluminum oxide air abrasion and hydrofluoric acid provided higher bond strength than treatment with either procedure used alone.

Masahio Aida et al (1995)[29] conducted study to evaluate the adhesion of composite resin to five surface conditions of porcelain and found, commercially available silane agents gave high bond strength without Hydrofluoric acid etching.

Karson A kupiec et al (1996)[30] evaluated various treatment regimens with the Pro Bond adhesive System. Surface procedures used were:(1) air abrasion with aluminium oxide 50 μ(2) 8% hydrofluoric acid, and air(3) air abrasion and hydrofluoric acid. The Component groups were (1) silane, primer, and adhesive; (2) silane and adhesive; (3) silane alone; (4) primer and adhesive; (5) primer alone; (6) adhesive alone; (7) Silane and pimer, and (8) no bonding agent. And concluded the combination of air abrasion and hydrofluoric acid on porcelain surface before bonding composite recorded the most consistently effective bond strengths and also indicated that silane treatment of porcelain is critical for development of suitable bond strength for composite.

Kwok-hung Chug et al (1997)[12]This study investigated the effect of surface treatments on the bonding strength of porcelain fused to metal prosthesis repair. The result of this study suggest that metal substrates treated with sandblasting and porcelain treated either hydrofluoric acid or sandblasting can increases repair strength.

S. Shahverdi et al (1997)[10] Examined the failures of composite resin porcelain interfaces under loading. Porcelain surfaces were roughened with burs or treated with hydrofluoric acid gel and/or sandblasted with a Microetcher. The result showed that there were differences both in the 24-hr and 30-day storage period bond strengths between the various surface treatment methods.

Stefanos g. kourtis (1997)[31] studied the bond strengths of resin- metal bonding systems. Six resin-to-metal bonding systems were tested: Silicoater, MD rocatec, OVS, Sebond and Spectra- link. All specimens were examined in bending tests after 24hrs of thermocycling and suggested that certain adhesive systems can provide satisfactory bonding of resins to metal substructure without the need for retentive metal configuration of the metal framework.

Charles Habib et al (1999)[32] Conducted study to evaluate shear bond strength of esthetic veneers to metal and found metal resin bonding technique had significantly lower shear bond strength than standard Porcelain found to metal.

Hiedeo matusumasra, saijii shimoe et al (1999)[33] studied the effect of noble metal conditioners on bonding between prosthetic composite material and silver –palladium – copper –gold alloy. Four primers such as Alloy Primer, Metalite, Metal Primer II and V- Primer were assessed and concluded the use of 1- liquid metal conditioners containing sulfur compound was a simple and useful method for improving bonding between the alloy and the composite material tested. This technique eliminates expensive and time consuming metal surface preparations and can be applied in fabrication of composite resin veneered restorations and intraoral facing repair.

Ibrahim Fevzi Tulunoglu et al (2000)[34] Studied the shear bond strengths of 4 porcelain repair systems. Metabond C&B, Silistor, Clearfil Lustre and Scotch bond, Multipurpose Plus to a base metal alloy and porcelain in relation with the polymerization shrinkage of a visible light-cured composite superstructure and compared with the ceramometal bond strength. The best results were obtained with the use of scotch bond Multipurpose Plus material.

James s. knight, dan sneed et al (2000)[35] studied the strengths of composite bonded to base metal alloy using 8 dentin bonding systems. All-bond 2 exhibited the highest mean shear bond strength and Panavia 21 with primer had the lowest in the test conducted. They concluded that dentin adhesive systems may be used to bond composite to base metal alloy with minimal surface preparation.

Susanne szep, Thomas Gerhard et a l (2000)[36] studied invitro dentinal surface reaction of 9.5% buffered hydrofluoric acid in repair of ceramic restorations using scanning electron microscope. Topical application of hydrofluoric acid appeared to provide a dentinal surface with an amorphous precipitate of fluoride. They suggested that the repair of fractured porcelain with hydrofluoric acid should be combined with a pretreatment of phosphoric acid on exposed dentin.

Debra R. Haselton Et al (2001)[37] Caculated the shear bond strength of 2 porcelain repair systems (Cojet – System and or Ceramic Repair). Cojet – system achieved significantly higher bond strength to porcelain and Metal substrates. Significant,but only within the ceramic Repair system.

Mutlu Ozcen et al (2002)[38] determined the reasons for and locations of failures of metal – ceramic restorations. A total of 153 patients possessing 289 fractured crowns were involved in this study; 255 of these fractures were in fixed partial dentures, whereas 34 were on single crowns. The majority of the failures (65%) occurred in the anterior region. Sixty percent of the failures were observed at the labial, 27% at the buccal, 5% at the incisal, and 8% at the occlusal regions. The fractures were mainly in the maxilla (75%) surface. The overall cumulative survival rates of the repairs (89%) showed that the first failures happened mostly from 1 week to 3 months after the repair.

Alvaro Della Bona, et al (2002)[11] tested the hypothesis of hydrofluoric acid treated ceramic surfaces produce the highest tensile bond strength to resin cements, independent of the ceramic microstructure and composition; and the tensile bond strength test is appropriate for analysis of interfacial adhesion for ceramic bonded to resin systems.

M.Ozcan (2003)[3] reviewed the alternative intra- oral repair techniques for fractured ceramic-fused-to-metal restorations. The repair material should have a minimal coefficient of thermal expansion and minimal polymerization shrinkage. Larger particle size composite resin also affects its bond strength than microfilled composite resins. Thermocycling decreased the bond strength as it weakens the resin structure. Organosilane coupling agents are not able to bond to metal surfaces as they do to dental ceramics. Hydrofluoric acid and acidulated phosphate fluoride facilitate micromechanical retention but are not applicable to the fractures where metal is exposed and they are also hazardous to soft tissues. Owing to the increasing number of composite resin materials on the market, it is still not easy to choose the best one.

Won-suck Oh et al (2003)[39] investigated the tensile bond strength of a composite to 3 dental ceramics by different surface roughening procedures on the ceramics. Surface treatment was 1.Polished 2. Air borne particle abraded with 50 µm Al_20_3. 3. Etching with 5% hydrofluoric acid gel and 4.A combination of airborne particle abrasion and etching. And found combined surface roughness was the most effective surface topography in terms of the bond strength increase.

Bo-Kyoung Kim et al (2005)[40] studied the tensile bond strength of composite resin to 3 different all ceramic coping materials with various surface treatments. Alumina and Zirconia ceramic specimens treated with a silica coating technique, and lithium disilicate ceramic specimens treated with airborne-particle abrasion and acid etching yielded the highest tensile bond strength values to a composite resin.

Tamiye Simone Gaia et al (2006)[41] Compared the microtensile bond strength of a repair resin to an alumina reinforced feldspathic ceramic after 3 surface conditioning methods. Etching with 9.6% hydrofluoric acid for 1 minute and application of silane for 5 minutes showed the best result. Scanning electron microscope analysis of the failure modes demonstrated predominantly mixed types of failures, with adhesive and / or cohesive failures.

Juliana Gomes dos Santos et al (2006)[3] evaluated the shear bond strength of different repair systems for metal-ceramic restoration applied on metal and porcelain. Resin composite repair systems used were Clearfil SE Bond 'Clearfil AP-X, Bistite II Dc/Palfique, Cojet Sand/Z100, Scotchbond Multipurpose Plus / Z100, or Cojet Sand plus Scotchbond Multipurpose Plus/Z100.The bond strength for the metal substrate was significantly higher using the CoJet system. For porcelain Scotchbond Multipurpose Plus, Cojet Sand/Z100 systems showed the highest shear bond strength values.

Pascal magne, domenico cascione(2006)[42] studied the influence of post- etching and connecting porcelain on the microtensile bond strength of composite resin to feldspathic porcelain. They suggested that using a standard bonding protocol(hydrofluoric etching, post etching cleaning, silanization, heat drying), resin- porcelain bond strength data indicate that the use of a wash of translucent porcelain to the refractory dies(connecting porcelain) is recommended rather than connecting paste. The leucite- reinforced heat-pressed porcelain exhibited the highest mean bond strength. Omission of specific post-etching cleaning regimen resulted in the lowest bond strength, because hydrofluoric acid etching generates a significant amount of crystalline debris, thus contaminating the porcelain surface.

Saadet saghan atsu, mehmet et al (2006)[43] studied the effect of zirconium-oxide surface treatments on the bond strength of adhesive resin and concluded that tribochemical silica coating (Cojet System) and the application of an MDP-containing bonding /silane coupling agent mixture increased the shear bond strength between zirconium- oxide ceramic and resin luting agent.

Boonlet et al (2007)[44] evaluated the effect of different etching times of Acidulated Phosphate fluoride gel on the shear bond strength of High leucite ceramics bonded to composite and found 7 minute 1.23% Acidulated Phosphate fluoride gel treatment produced shear bond strength comparable to a 4 minute treatment with 9.6% Hydrofluoric acid..

Yalcin Cifti ,Senay Canay, Nur Hersek (2007)[45] evaluated the shear bond strength of 4 esthetic veneering materials on Nickel-Chromium alloy-Artglass, Targis/Vectris & Biodent composite resins were used .They concluded

Targis/Vectris showed the higher bond strength values than the other two groups.

Lisa.A. Knobloch et al(2007)[46] studied the bond strength of one and two-step self –etch adhesive systems and concluded that placement of an intermediary elastic layer of flexible composite resin between the self-etch adhesive and bulk composite does not result in an increase in bond strength.

Aspasia Sarafianou et al (2008)[15] examined the shear bond strength of an indirect composite resin to a Ni-Cr-alloy, using 4 primers and 2 airborne- particle abrasion procedures with 50µm $A1_20_3$ particles, and with 250µm $A1_20_3$ particles. Airborne particle abrasion with 5Oµm $A1_20_3$ particles may result in improved bond strength, independent of the primer used.

Shaghayegh Parvizi, E etal (2008)[47] Assessed the effect of surface acid etching on the biaxial flexural strength of two hot- pressed glass ceramics reinforced by leucite or lithium disilicate crystals No significant interaction between the ceramic type and etching process was found it was concluded that surface Hydrofluoric acid etching could have a weakening effect on hot – pressed leucite or Lithia disilicate-based glass ceramic systems.

Sosan Mir Mohammad Rezai et al (2008)[48] evaluated the influence of different ceramic surface treatment on the micro-shear bond strength of composite resin to IPS Empress 2 coping material. Among the investigated methods, silane coating after airborne particle abrasion and etching was the most effective surface treatment in terms of bond strength.

Hercules Jorge Almilhatti et al (2009)[49] studied adhesive bonding of resin composite to various Nickel-Chromium alloy surfaces using different metal conditioners such as Metal photo primer MPP), Cesead II Opaque Primer(OP), Targis Link(TL) & surface modification system Siloc. He concluded the OP & TL conditioners and surface sandblasting with 250 µm Al_2O_3 promoted highest shear bond strength between resin and Nickel-Chromium metal surface.

Petra Schmage(2009)[50] studied the effect of surface conditioning on the retentive bond strengths of fiber reinforced composite posts and suggested that the retentive bond strength of FRC post can be improved only for specific core foundation composite resins by conditioning the post surface with the CoJet system or with Hydrofluoric acid etching.

Nadia Z fahmy et al(2010)[51] studied an alternative indirect treatment to repair a fractured or chipped veneering metal ceramic using recently developed ultra low fusing ceramics.In this study one conventional feldspathic ceramic ,Vita Omega & 3 ultra low fusing ceramics (ULFC), Finesse, Duceram LFC , Vision-Low were used. They concluded Omega Duceram LFC yielded the highest bond strength & lowest biaxial strength. ULFC (Finesse & Vision-Low) recorded bond strength equal to that of resin-ceramic direct subgroup.

MATERIALS USED IN THE STUDY

Cold cure resin –**HIFLEX**

Inlay Wax-UNIWAX

Sprue Wax

Phosphate bonded Investment

Nickel-Chromium Alloys

Alumimium Oxide Powder

Porcelain-DENTSPLY

Build up liquid & Firing tray

Dye Solution- Basic Fuschin

PORCELAIN REPAIR SYSTEM

Silane coupling Agent

Bonding Agent

Ivoclar Composite Material

3M Composite Material

Dentsply Composite Material

Composite Polishing Kit

EQUIPMENTS USED IN THIS STUDY

Vaccum power mixer

Burn Out Furnace

Induction casting machine

Ceramic Burn out Furnace

Light Cure Unit

Lyold's Mechanical Testing Machine

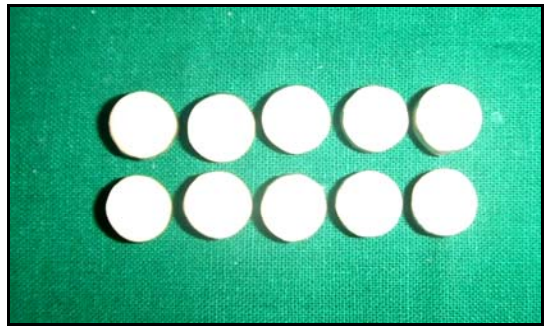
Metal Die

Resin Patterns

Sprued Resin Patterns

Casted alloy Samples

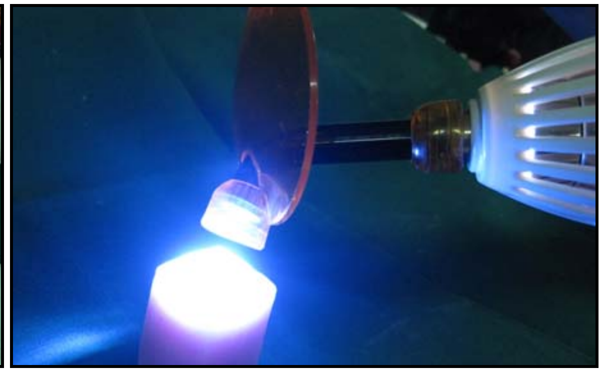
Metal discs *CONTROL Group : Porcelain Veneered Disc samples*



Half Veneered Porcelain Disc samples

Porcelain Veneered Disc embedded in Acrylic Block

Silane application *Composite application*



Half Veneered Porcelain Disc repaired with IVOCLAR composite material

Half Veneered Porcelain Disc repaired with 3M composite material

Half Veneered Porcelain Disc repaired with DENTSPLY composite material

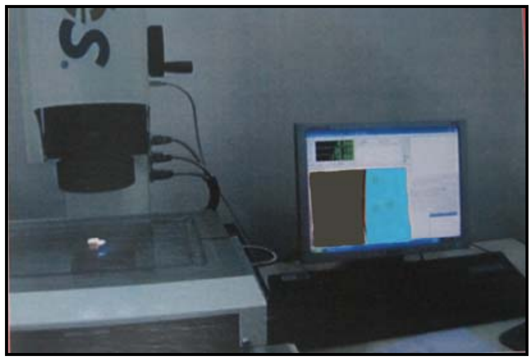
Testing of Shear bond Strength-Positioning the Sample

Breaking of the sample

Samples sectioned after Dye immersion

IVOCLAR	*3M*	*DENTSPLY*
		

Video measurement system



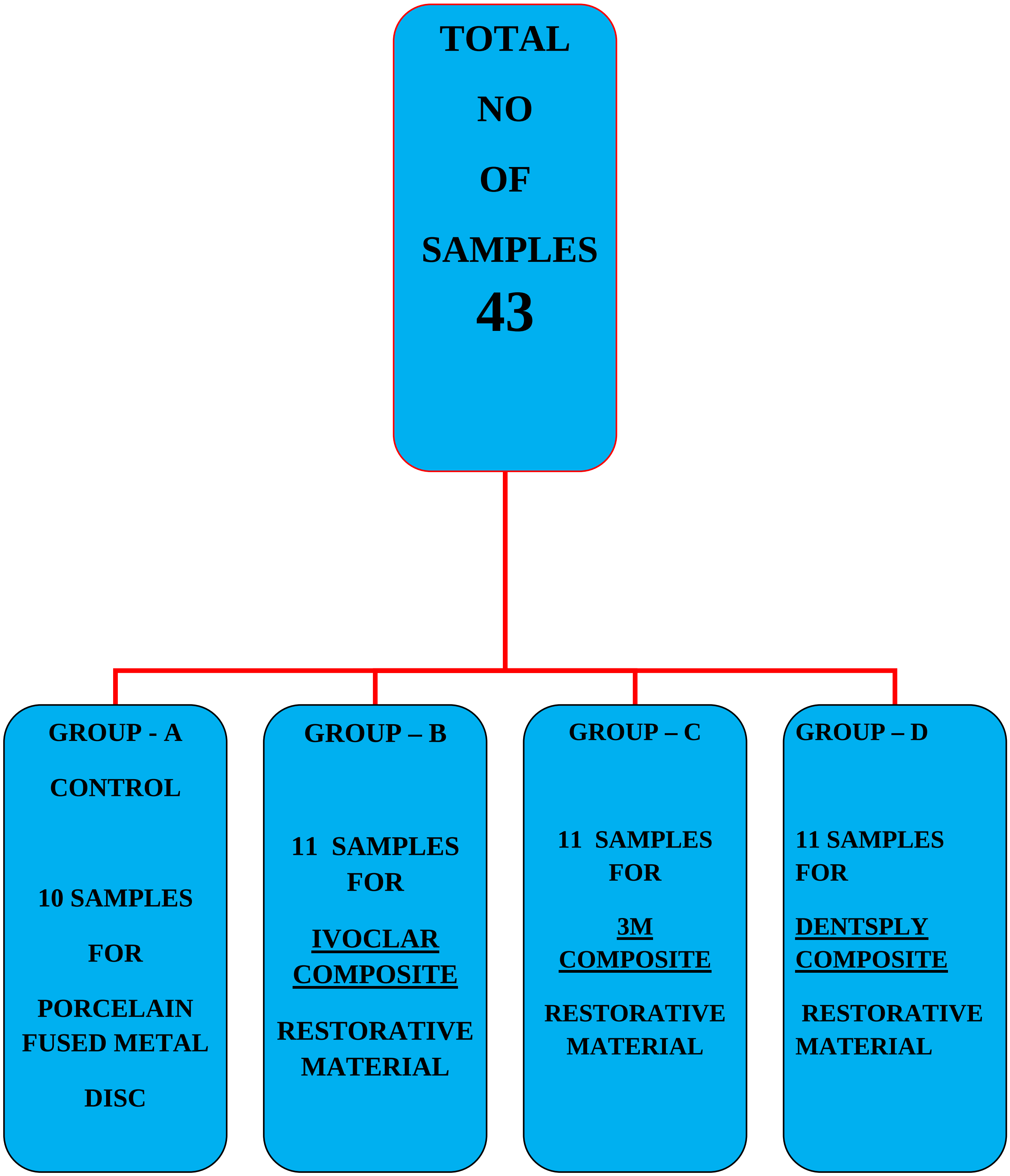
Bonding Interface between Composite& metal

IVOCLAR	*3M*	*DENTSPLY*
		

Bonding Interface between Ceramic &Composite

IVOCLAR	*3M*	*DENTSPLY*
		

FLOW CHART OF SAMPLES PER TREATMENT



MATERIALS AND METHODS

The present invitro study was conducted to evaluate and to compare the shear bond strength of repaired porcelain fused restorations using different commercially available composite resins. This study also involved to evaluate the bonding ability at the interface between composite resin-metal and composite resin- ceramic interface

GROUPING OF SAMPLES:

The study was categorized based on the different types of commercial composite restorative materials used, and classified into four groups with one control group of 10 specimens and 11 specimens in each test group. So a total of 43 specimens were prepared.

GROUP A: control group-consists of 10 samples for porcelain fused metal disc

GROUP B: consists of 11 samples for Ivoclar composite resin

GROUP C: consists of 11 samples for 3M composite resin

GROUP D: consists of 11 samples for Dentsply composite resin

MATERIALS USED IN THIS STUDY:

.

Sl no	Materials	Manufacture name
1	Cold cure resin	Hiflex
2	Inlay wax	Uniwax (Delta)
3	Sprue wax 2.5mm diameter	Bego (Germany)
4	Phosphate bonded investment	Deguvest (Germany)
5	Ni Cr alloy pellets	Haraneium-s,(Germany)
6	Feldspathic porcelain	Dentsply

PORCELAIN REPAIR SYSTEM:

Sl no	Materials	Manufacture name
1	Monobond- S	Silane, Ivoclar vivadent
2	Bonding agent	Heliobond- Ivoclar Vivadent
3	Monopaque,Microhybrid composite, Ivoclar	TeEconoum Plus, Ivoclar Vivadent
4	Monopaque,Microhybrid composite,3M	Z100TM restorative
5	Monopaque,Microhybrid composite,Dentsply	Spectrum

EQUIPMENTS USED IN THIS STUDY

Sl no	Equipments	Manufacture name
1	Vacuum power mixer	Bego, Germany
2	Burn out furnace	Bego, Germany,
3	Induction casting machine	Bego, Germany
4	Dental ceramic furnace	Vita-vacumat 100
5	Light cure unit	3M Unitec , germany
6	Mechanical testing machine	Lloyd's instrument, UK

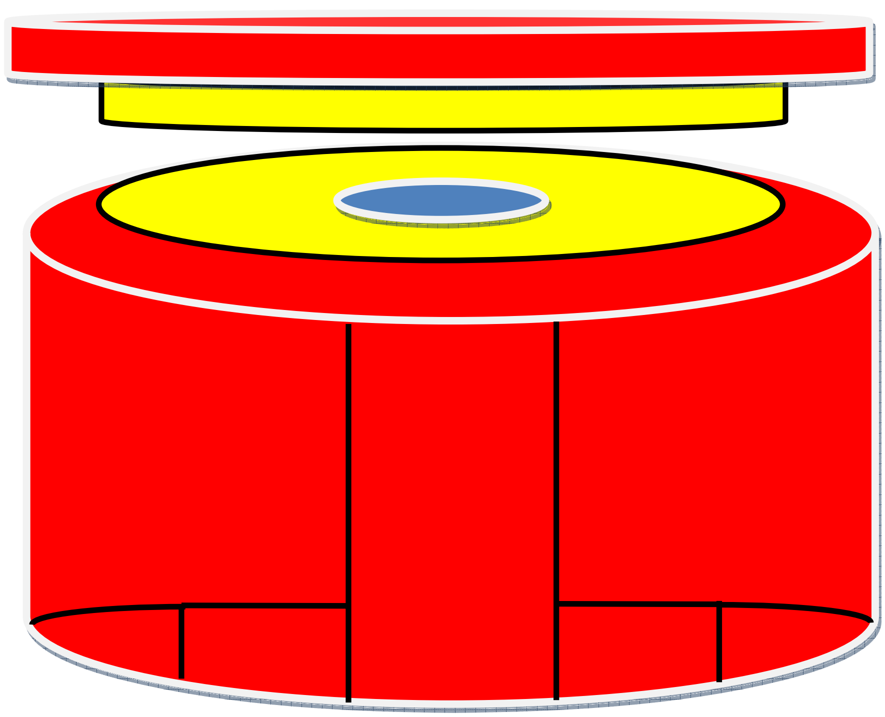
METHODOLOGY:

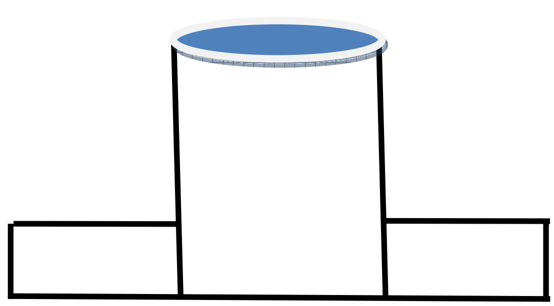
1. Preparation of the metal die for fabrication of resin patterns
2. Preparation of the resin patterns
3. Spruing and Investing the resin patterns
4. Casting & Finishing the resin patterns
5. Veneering of metal substructure with ceramic
6. Embedding the cast samples in acrylic block.
7. Surface treatment of test specimens
8. Application of light cure composites
9. Thermocycling
10. Testing the finished samples
11. Sectioning of test samples

1. PREPARATION OF THE METAL DIE FOR FABRICATION OF RESIN PATTERNS

A split circular steel die was machined in the lathe in such a way that it consists of three separate parts mounted one above the other, and locked to produce the required samples

SCHEMATIC REPRESENTATION OF CIRCULAR METAL DIE FOR FABRICATION OF ACRYLIC RESIN DISC PATTERNS





A. THE LOWER OR BASAL PART: It consists of flat table and one vertically aligned bar in the centre which have hole corresponding to the bar in the middle part, so that the bar passes through in the other two parts to obtain firm closure. In order to verify the correct alignment, indexing marks are provided on the outer side of the three parts.

B.MIDDLE OR PERFORATED PART: It has one hole of 1cm diameter and 2mm thickness, in to which resin can be poured to obtain patterns.

C.THE UPPER OR LID PART: It is used to lock the middle part after the resin has been poured and hence patterns can be obtained to the desired dimensions.

2. PREPARATION OF RESIN PATTERNS; The metal die was lubricated with petroleum jelly and used for preparation of resin patterns. 43 disc shaped resin patterns of dimensions 1cm and 2mm thickness were prepared using autopolymerising acrylic resin.

3. SPRUING AND INVESTING THE RESIN PATTERNS:

A 2.5mm diameter sprue wax was attached to the centre of the under surface of resin pattern and a reservoir was added on the sprue 2mm away from the pattern. A ringless casting technique was employed. A flexible silicone casting ring was used for investing purpose. Six acrylic resin patterns were arranged in a circular pattern on the crucible base such that the patterns were approximately 6mm from the top of the ring and 3mm from the wall of the casting ring. They were separated from each other by a distance of 3mm. Surfactant were applied to the patterns and left to air dry. A phosphate bonded investment(Deguvest) was mixed with silica sol in the proportion of 150gm of powder to 35ml of liquid according to manufacturer's instruction using a vacuum mixer.

The silicone ring with resin samples was placed over a mechanical vibrator and then invested. The investment was allowed to set for one hour and was placed in the burnout. Burnout of resin patterns was done using a programmed preheating technique.ie. The ring was kept in the room temperature and was heated to 950^0c at the rate of 8^0c/min and held for 30min at 950^0c.

4. CASTING AND FINISHING THE SAMPLES:

Casting was done in Induction casting machine. Nickel chromium alloy was used to metal substructure samples. Investment was allowed to cool to the room temperature. Divestment was done and the casting was retrieved. The same procedure was carried to prepare for all the specimens. A total of 43 specimens were obtained. All the metal substructure were subsequently finished and sandblasted.

5. VENEERING THE METAL SUBSTRUCTURE WITH CERAMIC:

The upper surfaces of all the metal samples were sandblasted and steam- cleaned for addition of ceramic. Out of 43 samples, 10 samples were allotted for control group and then upper surface were fully veneered by porcelain. Where as in the other 33 test samples only one half of the upper surface is veneered by porcelain of 2mm thickness, and the other half of the surface is kept free for veneering by composite resins.

The following schedule was followed for application of porcelain by layering technique.

Degassing: By placing the metal disc directly at 1200 ^{0}F(650) and the elevating the temperature at the rate of 15 ^{0}F(31 ^{0}C) per minute. Final temperature of 1925 ^{0}F(1050^{0}C) is reached – for 15 minutes. After degassing the metal disc were cooled in open air.

Opaque porcelain: applied to a thickness of 0.5mm and condensed by vibration.

Dried by placing them on firing tray on a hot plate 700^{0}F (370^{0}C) 20 minutes.	→	Transferred to the furnace already preheated to 1200^{0}F (650^{0}C).	→	Maximum temperature 1750^{0}F(950^{0}C) in partial vaccum(720mm|Hg)

Body porcelain: Added to all specimen of 1.5mm uniform thickness

Dried by placing them on fining tray on a hot plate 700^0 F (370^0 C) 20 minutes	→	Transferred to the furnace already preheated to 1200^{0}F (650^{0}C).	→	Maximum temperature 1750 ^{0}F(950^{0}C) in partial vaccum(720mm|Hg)

After reaching 1750 ^{0}Fthe vacuum was released and the metal discs were allowed to air fire an additional minute at 1750^0F(950^0C). A patch bake of body porcelain was accomplished using the same procedures.

Before glazing the metal discs were properly finished to attain correct thickness.

Preheated to 700^0F (370^0C) → Transferred to the furnace already preheated to 1200^0F (650^0C). → Maximum temperature 1800^0F (980^0C) atmospheric pressure for 3 mints

A total of 43 porcelain fused discs of uniform thickness were made.

6. EMBEDDING THE TEST SAMPLES IN THE ACRYLIC BLOCKS:

The test samples were embedded in the blocks of acrylic, this was done to hold the test samples in the testing machine.

7. SURFACE TREATMENT OF TEST SPECIMENS:

SANDBLASTING: sandblasting of the porcelain and the metal surfaces of the test samples (30 samples) were done with 50 µm Al_2O_3 for 30 seconds under 4 psi pressure. After sandblasting the specimens were cleaned with stream of water and were dried thoroughly with oil free compressed air.

8. APPLICATION OF COMPOSITE RESINS: After the satisfactory preparation of the surfaces, each test samples of each test groups were subjected to application of silane coupling agent, light cure opaque and bonding agent prior to the addition of composite resin.

Application of silane coupling agent: It is applied over the unveneered surface of metal samples and surface of ceramic interface with the help of the brush provided by the manufacturer and was allowed to dry for 5minutes

Application of light cure opaque: It was painted on the exposed metal surface to mask the exposed metal and was cured according to manufacturer's instructions.

Application of bonding agent: Applied both in the metal and ceramic surface as per manufacturer's instructions.

Addition of composite resin: Three different commercially available composite restorative materials were added over the unveneered surface of the metal disc treated with bonding agent with the help of custom made transparent semicircular plastic tube of 5mm radius and 2mm thickness to standardize the dimensions of composite for all samples. Composite was light cured for 60 seconds. Same procedure was carried out for all the test samples. Then all samples were finished and polished with Shofu composite finishing and polishing kit.

9. THERMOCYCLING:

To evaluate the durability of bond strength between composite resin and ceramic & metal interface, thermocycling was performed. In this procedure the samples were exposed to temperatures of approximately 5^0C and 55^0C alternatively with an immersion time of 10 seconds in each. This immersion in cold and hot temperatures for 10 seconds in each completes one cycle. In such a way 500 cycles were completed and then samples were subjected to testing for shear bond strength.

10. SHEAR BOND TESTING:

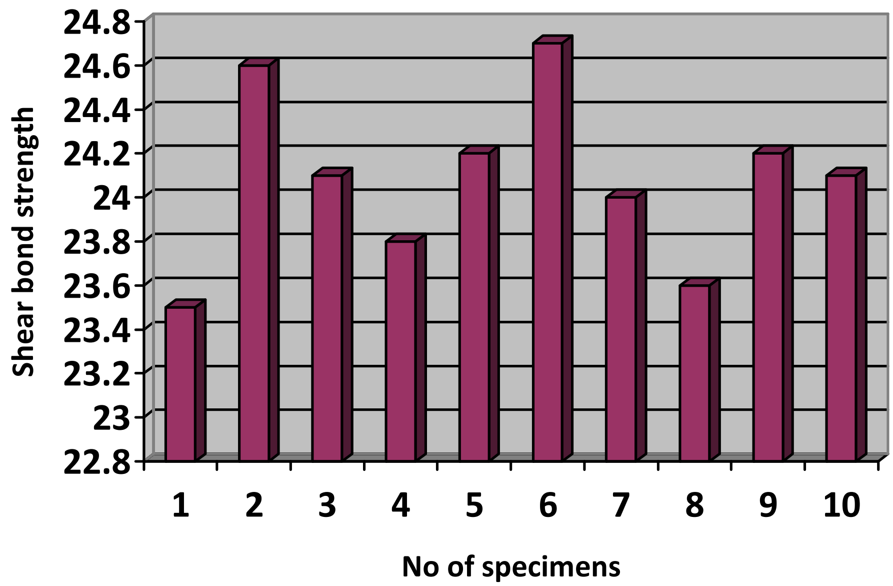
Shear bond strength of the different commercially available composite repair material was determined by using Lloyd's Universal Testing Machine (floor type) with the cross head speed of 1mm/minute. The test samples were positioned in such a way that the shearing blade was flush on the metal surface and perpendicular to ceramic and composite interface. Force was applied with a 50kg compression load cell. The maximum load required to fracture a sample divided by the bonded area was recorded as the shear strength of that particular sample. Values of the shear bond strength in MPa were obtained with the help of a computer attached to the testing machine.

11. SECTIONING OF TEST SAMPLES:

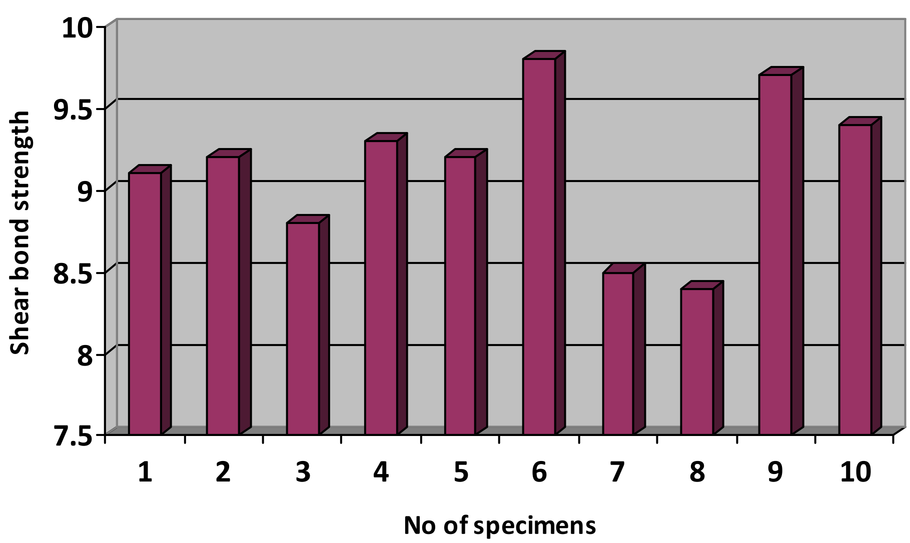
Dye penetration test was used to assess the bonding interface adaptation. The principle involved in this technique is liquid enter small openings by capillary action. Rate and action of dyes depends on condition of the surface material and interior discontinuity[52]. From each group (Ivoclar, 3M, Dentsply) 1 sample was immersed in 0.1% basic fuschin and kept in vacuum flask at 37^0C for 24 hrs.

After exposure to dye, the samples were rinsed in running water to remove dye from the external surface. Then the samples were sectioned using diamond disc. And the dye penetration interface was assessed using video measurement system at magnification of 40X- to evaluate bonding ability between the composite-metal and composite- ceramic interface.

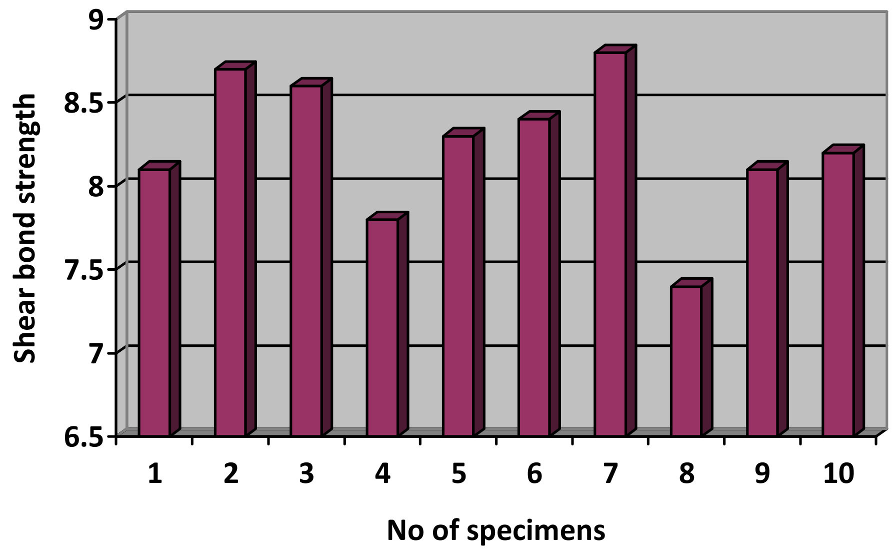
BASIC VALUES OF SHEAR BOND STRENGTH OF GROUP-A



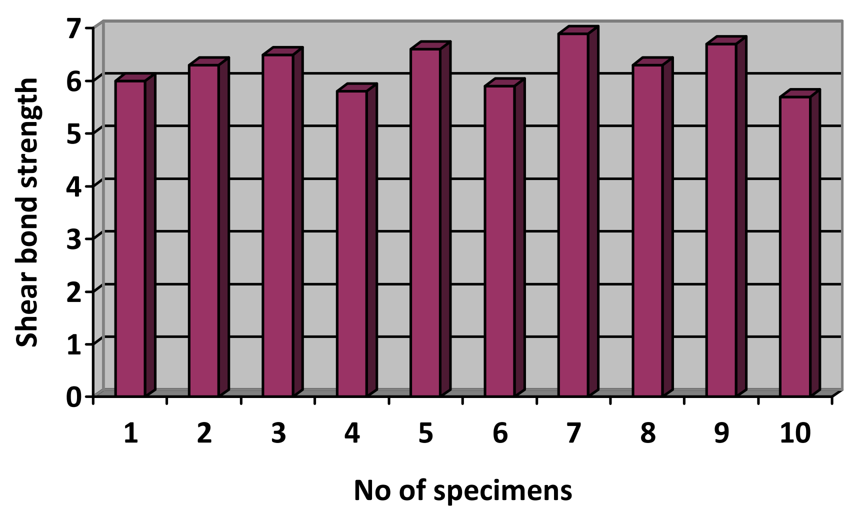
BASIC VALUES OF SHEAR BOND STRENGTH OF GROUP-B



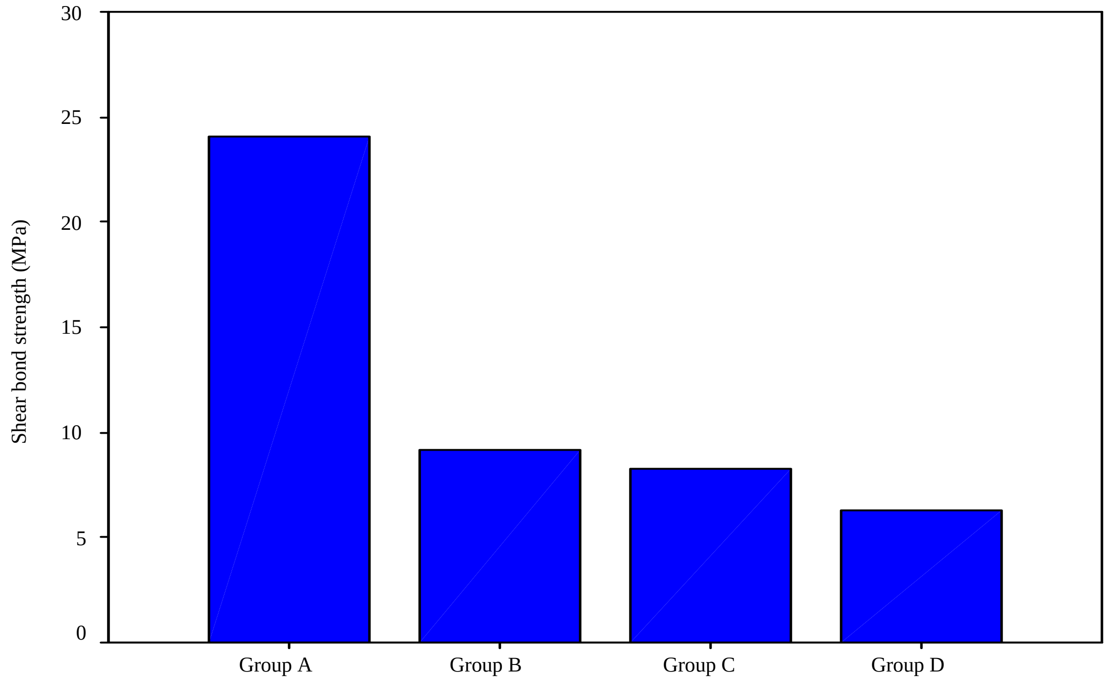
BASIC VALUES OF SHEAR BOND STRENGTH OF GROUP-C



BASIC VALUES OF SHEAR BOND STRENGTH OF GROUP-D



MEAN VALUES OF SHEAR BOND STRENGTH OF GROUP-A, GROUP-B, GROUP-C AND GROUP-D



RESULTS

This invitro study was performed to evaluate and to compare the shear bond strength of repaired porcelain fused metal restorations by using different types of commercially available composite restorative materials and its interface adaptation.

Samples were divided into four groups, with one control group (Porcelain Fused Metal restorations) of 10 specimen and three test groups based on types of composite materials of 11 specimens each (Ivoclair, 3M, Dentsply). 10 samples from control group and 10 samples from three test groups were tested for shear bond strength test after thermocycling and 1 sample from each test group were tested for bonding interface adaptation. Data obtained as each group as mentioned below and were subjected for statistical analysis.

GROUP A: control group- for porcelain fused metal disc

GROUP B: Repaired using Ivoclair composite resin

GROUP C: Repaired using 3M composite resin

GROUP D: Repaired using Dentsply composite resin

TABLE 1

Group A -CONTROL GROUP basic values of shear bond strength of porcelain fused metal

No of specimens	Shear bond strength
1	23.5
2	24.6
3	24.1
4	23.8
5	24.2
6	24.7
7	24.0
8	23.6
9	24.2
10	24.1

MEAN =24.08

TABLE: 2

Group B -TEST GROUP basic values of shear bond strength of Ivoclar composite restorative material

No of specimens	Shear bond strength
1	9.1
2	9.2
3	8.8
4	9.3
5	9.2
6	9.8
7	8.5
8	8.4
9	9.7
10	9.4

MEAN=9.14

TABLE: 3

Group C-TEST GROUP basic values of shear bond strength of 3M composite restorative material

No of specimens	**Shear bond strength**
1	8.1
2	8.7
3	8.6
4	7.8
5	8.3
6	8.4
7	8.8
8	7.4
9	8.1
10	8.2

MEAN=8.24

TABLE: 4

Group D-TEST GROUP basic values of shear bond strength of Dentsply composite restorative material

No of specimens	**Shear bond strength**
1	6.0
2	6.3
3	6.5
4	5.8
5	6.6
6	5.9
7	6.9
8	6.3
9	6.7
10	5.7

MEAN=6.27

The results were subjected to statistical analysis:

Mean and the standard deviations were estimated from the samples of each study group. The data were then analyzed by the use of one way analysis of variance followed by Tukey HSD test. In this test $p<0.05$ was considered as the level of significance.

One way analysis of variance was used to calculate **p-value.** Tukey HSD test was used to calculate multiple comparisons.

TABLE: 5

The test of significance for the mean obtained from four groups

GROUPS	Mean	SD	P value
Group A	24.0800	.38528	**P**< 0.001**
Group B	9.1400	.46236	
Group C	8.2400	.42479	
Group D	6.2700	.40838	

The mean Shear bond strength of four groups is significance at 1% level.

TABLE: 6

Comparison between Shear bond strength

of group A with group B,C,D

(I) Group	(J) Group	Mean Difference (I-J)	P value
Group A	Group B	14.9400(*)	< 0.001**
	Group C	15.8400(*)	< 0.001**
	Group D	17.8100(*)	< 0.001**

The mean difference is significant at the .05 level

TABLE: 7

Comparison between Shear bond strength

of group B with group C,D

(I) Group	(J) Group	Mean Difference (I-J)	P value
Group B	Group C	.9000(*)	< 0.001**
	Group D	2.8700(*)	< 0.001**

The mean difference is significant at the .05 level.

TABLE: 8

Comparison between Shear bond strength

of group C with group D

(I) Group	(J) Group	Mean Difference (I-J)	P value
GROUP C	Group D	1.9700(*)	< 0.001**

The mean difference is significant at the .05 level.

INTERPRETATIONS OF THE RESULTS

1. Table:1 shows the basic values of shear bond strength of porcelain fused metal, **Group A** -(CONTROL GROUP)
2. Table:2 shows the basic values of shear bond strength of Ivoclar composite restorative material, **Group B** (TEST GROUP)
3. Table:3 shows the basic values of shear bond strength of 3M composite restorative material, **Group C-(**TEST GROUP)
4. Table:4 shows the basic values of shear bond strength of Dentsply composite restorative material **Group D**(TEST GROUP)
5. Table:5 shows the test of significance for the mean obtained from four groups
6. Table:6 shows the comparison between Shear bond strength of group A with group B,C,D
7. Table:7 shows the comparison between Shear bond strength of group B with group C,D
8. Table:8 shows the comparison between Shear bond strength of group C with group

DISCUSSION

Porcelain fused to metal restoration have been in use for more than five decades due to their improved mechanical properties and excellent biocompatibility. They are not only the restorative option for anterior esthetic zone but also choice of restoration in the posterior load bearing areas where considerable occlusal forces are encountered.

Although the ceramic materials provide an excellent restorative service over the years fractures of ceramic and ceramometal restorations is frustating but not uncommon problem in restorative dentistry. Various reasons cited for such failure include sudden impact load, porcelain fatigue, microdefects within the material, trauma and faulty technique employed during fabrication of porcelain restoration[53]

Fracture of such restorations does not necessarily mean complete failure moreover remaking a new prosthesis in such situations is both costly and time consuming. In addition removal of this prosthesis without damaging the underlying prepared teeth is also a cumbersome procedure especially in nonvital root treated teeth. In the anterior esthetic zone fractured ceramometal restoration is considered as an esthetic emergency and calls for immediate attention. Fractured porcelain crowns even in the posterior region should not be left untreated as the cracks & crazing in the defect might become a heaven for plaque and microorganisms which eventually leads to staining and marginal opening.[3]

Repair of fractured porcelain restoration depends on mode of fracture. If the porcelain fracture happens to be mild to moderate repair can be attempted intraorally instead of replacing the entire restoration.

Various technique have been advocated for repairing porcelain fused metal restorations such as overcasting, pin retained casting, cyanoacrylate, acrylic resin material, but the results of these earlier repairs were unsatisfactory because of aesthetic and mechanical limitations.[18] Overcasting, pin retained casting were dependent on mechanical retention and agents such as cyanoacrylate, acrylic resin showed limited success because of their inherent physical properties like wear, abrasion, marginal percolation and discolouration.[5]

As an alternative, composite resins have been used for repair. Composite resin has become the material of choice for such procedure due to their better shade matching and ease of manipulation.[8,9] But porcelain being glass in nature does not offer bonding to composite and traditionally relied on mechanical roughening of the fractured surface, followed by application of a silane coupling agent to enhance the resin to porcelain bond.[10]

Mechanical roughening of porcelain surfaces with a coarse diamond has improved repair strength. Air abrasion with aluminium oxide is another method of surface roughening, and porcelain can also be etched with hydrofluoric acid, phosphoric acid and Acidulated Phosphate Fluoride to facilitate microchemical retention of composite resin[3,4,].[11,12,]

Intra-oral repair systems based on topical acid application have become very popular in bonding resin to ceramic. The greatest advantage of these systems is that chair- side application and easy to execute. Furthermore the restoration can be re-etched in case of failure without the need for sophisticated laboratory procedure.

The most often cited etching for the ceramic surface is hydrofluoric acid. Despite its effectiveness, hydrofluoric acid presents severe hazards to human tissue as it has a caustic effect on the soft tissue. In higher concentration hydrofluoric acid can burn the soft tissue and skin which result the need for more reasonable repair alternatives.[10,12]

One easy method for intra-oral repair is roughening the fracture by sandblasting with Al_2O_3, thereby increasing the surface area for bonding and decreasing the surface tension. This technique is based on direct sandblasting of the surfaces by a intraoral device which provides micromechanical retention. Physical alteration of ceramic surface with Al_2O_3 was mostly achieved using a particle size of 50µm.[15] Air abrasion improves the retention between the metal and the resin by cleaning oxides or any greasy materials from the metal surfaces, creating very fine roughness enhancing mechanical and chemical bonding between resins and metals. When Al_2O_3 treatment was performed on the alloy casting, microscopically cleaned surfaces were observed.

Sandblasting was described as the most effective surface treatment of fractured metal- ceramic restorations irrespective of the type of surfaces.

Guggenberger (1989) introduced a new technique for bonding acrylic - metal system where a tribochemical application of a silica layer by means of sandblasting was advocated. This system exhibited better bond strength but require specialized equipments which questions its cost effectiveness.[15,41]

M.Ozacan in a review revealed that the most effective surface treatment is combinations of mechanical roughening with Al_2O_3 followed by chemical etching with hydrofluoric acid.[3] It was found that the durability of bonds between composite and ceramic formed with chemical agents were markedly inferior to alteration of ceramic surface with either Al_2O_3 abrasion or a combination of both chemical and mechanical roughening.[28] Belly J.H demonstrated the benefit of using vinyl silane as an organo functional coupler between the polymer and inorganic substances in promoting the quality of the bond. Presently, several porcelain system that are rely on chemical interactions (silane coupling) which are commercially available.[13,19,24]

Silane coupling agents were first introduced in 1960 by Bowen and Rodriguez.[9] Chemical bonding to ceramic surface is achieved by silanization with a bifunctional coupling agent. A silane coupling agent at one end chemically bonds to hydrolyzed silicon dioxide of the ceramic surface and a methacrylate group at the other end co-polymerize with the adhesive resin.

Keeping the above mentioned bonding mechanisms, this invitro study was undertaken to evaluate and compare the shear bond strength of repaired porcelain fused metal restorations with different commercially available composites and its interface adaptation.

To perform the study 43 standardized test samples with metal ceramic test surfaces were fabricated in view of the test requirements and according to manufacturer recommendation. The samples were then divided into one control group with fully veneered porcelain surface of 10 specimens and three test groups half veneered porcelain surface of 11 specimens each.

Surface preparations of the three test groups were done with 50 µm Al_2O_3 for 30 seconds under 4psi.

50 µm Al_2O_3 were used as standard surface treatment for this study because this provides better bonding as compare to 250 µm Al_2O_3 and also used intra-orally without any hazards.[15]

Silane coupling agent (mixture of ethanol, water, and 1% 3Methacryloxy propyl-tri methoxy silane) was applied to the ceramic surface. Silane was applied only on ceramic surface because Ozacan in his review stated that organosilanes did not bond to the metal surface as they had with the ceramic. Then opaque resin for the metal followed by bonding agent, microhybrid composite resins of three different types(Ivoclair, 3M, Dentsply) were added.

Composite resin is composed of four major components: organic polymer matrix, inorganic filler particles, coupling agent and intiator-accelerator system. The organic polymer matrix is either aromatic or urethane diacrylate oligomer. Inorganic filler particles include colloidal silica, quartz. Coupling agents are used to form between organic and inorganic phases of composites. Initiators and accelerators allows for self curing, light curing, dual curing.[53]

In this study light cured composite resins were used. The depth of light penetration into a composite restoration depends on the wavelength of light used. The concentration of photo-initiator should be such that it will react in proper wavelength and must be present in sufficient concentration.[53]

For the polymerization to begin a source of free radicals is required. When the photo initiator (Camporoquinone) is exposed to light at wavelength of 468nm, it is activated to an excited state, which interacts with the dimethylaminoetylmethacrylate(DMAEMA) to generate free radicals at the double bond. This free radical bonds with one side of monomer molecule and form free radical at other end. Thus the reaction is initiated.[54]

For repair purposes, use of the hybrid composite resins was advised as suitable ones. Microfilled composites with smaller and more numerous particles scatter more light than the microhybrid composites.[12] Longer exposure times are needed to obtain adequate polymerization of microfilled composites. The problems of wear and surface changes of a repair material is related to the use of the microfilled composite resin which could be minimized if a hybrid composite resin is used.[27] So, we used microhybrid composite resin for this study to repair the porcelain fracture.

All the samples were thermocycled. Newburg and Pameijer found application of silane significantly increased the bond strength and thermocycling had no adverse effect on bond strength properties. However many studies showed conflicting results that show thermocycling and long term water storage decreased the bond strength of repaired Porcelain Fused Metal restorations significantly. Therefore thermocycling and water storage can be recommended to determine the durability of composite to Porcelain Fused Metal restoration and the cohesive strength of composites[12].

Tjan E.T al stated that conditioning at 100% humidity at 37^0C in some instances weakened the bonding. They suggested various factor that may contribute to the weakening of the bond. (1). Reaction with the water, such as hydrolysis and expansion of the primer or composite due to water sorption. (2).Stresses developed at the interfaces between the materials due to expansion; and (3). Stresses resulting from the difference in the coefficient of thermal expansion of resin and porcelain.[5]

About 0.1% basic fuschin dye is used for dye penetration test to study the closer adaptation of composite to ceramic and metal at the fracture interface. The sectioned samples of each test groups are immersed in 0.1% basic fuschin about 24hrs at 37^{0}C and studied video measurement system[55].

Hence an attempt was made to study the shear bond strength of repaired porcelain fused metal restoration by using different types of commercially available composite restorative materials and its interface adaptation.

Results obtained showed basic data of the shear bond strength exhibited a mean value of 24.08 for group A, 9. 14 for group B, 8.24 for group C, 6.27 for group D. Maximum value of shear bond strength of composite restorative material with porcelain and the metal substructure were obtained with group B(Ivoclar) followed by group C(3M) and group D(Dentsply).

Data analyzed by use of ANOVA test followed by Tukey HSD test of multiple comparisons indicated that p-value less than 0.05 denotes significant difference between four groups. Inter group comparisons of data using Tukey HSD test of multiple comparisons indicated that $p<0.001$ when group A is compared with group B, group C and group D. And same p-value existed when group B is compared with group C and group D and also when group C is compared with group D. The results does not support the null hypothesis.

The dye penetrated test samples assessed by video measurement system showed that Ivoclar composite material showed closer bonding interface adaptation to metal and ceramic interfaces.

At present the minimum bond strength for retention of an adhesive to a metal ceramic restoration in the oral environment is not known. Maximum bite force ability of each patient, the estimated biting force on specific tooth, the presence and absence of surface damage may affect the success rate. [3,38]

Before making an attempt to repair the porcelain fracture in porcelain metal restorations, the underlying metal substructure should be sound without porosity and is not the real cause of failure. If this is the reason, instead of attempting repair process the restoration should be renewed.

The complexities of oral environment and the surface topography of dental restoration make it difficult to precisely define the magnitude and the mode of stress involved in clinical fracture of porcelain fused metal restorations. The laboratory cannot accommodate intraoral variables and the complexities of oral environment, more over repairing the porcelain fused metal restorations in the laboratory or remaking is a costly affair. Further studies are required to predict the effective performance of ceramic repair system.

SUMMARY AND CONCLUSION

Ceramic materials provide an excellent restorative service over years however the fracture of Porcelain Fused Metal restorations is a common problem faced in routine practice. Making of a new prosthesis in most of the instances is both costly and time consuming and hence repair may be indicated. The suitable repair material which is regularly used in repair of Porcelain Fused Metal restorations is composite resins.

This invitro study was performed to evaluate and to compare the shear bond strength of repaired porcelain fused metal restoration by using different types of commercially available composite restorative materials and its interface adaptation.

Samples were divided into four groups, with one control group (Porcelain Fused Metal restoration) of 10 specimen and three test groups based on types of composite restorative materials of 11 specimens each. (Ivoclar, 3M, Dentsply). 10 samples from control group and 10 samples from three test groups were tested for shear bond strength test and 1 sample from each test group were tested for bonding interface adaptation. The results obtained were statistically analyzed.

Within the limitations of the present study and from the results obtained the following conclusions were drawn.

1. The bond strength of conventional feldspathic Porcelain Fused Metal restoration was significantly higher than that of composite restorative materials to metal bonding systems.
2. Ivoclar composite repair material showed higher bond strength values than 3M & Dentsply composite restorative materials. But 3M showed higher bond strength values than Dentsply.
3. Dentsply composite restorative material showed the lowest bond strength values of the three tested material.
4. Bonding interface adaptation was more closer for Ivoclar composite restorative material.

The results of the study showed that the Ivoclar composite restorative material could provide better bond strength as compared to that of 3M & Dentsply composite repair materials. However further longitudinal studies under conditions simulating the oral environment are needed to prove the success and longevity of ideal porcelain fused metal repair composite material.

BIBLIOGRAPHY

1. **Ceard Heather .J -** Current Ceramic materials and system with clinical recommendation; a Systematic review.
2. **John W Mclean -** The science & art of Dental Ceramics Volume I & II.
3. **Juliana. G Dos, S Fonseca R. G -** Shear bonding strength of metal ceramic repair system Journal of Prosthetic dentistry 2006;Vol 96;165-173.
4. **Tjan AHC, Dent, Herald N -** Bond strength of composite to metal mediated by metal adhesive promoters .Journal of prosthetic dentistry 1987;volume 57;550-554.
5. **Barzilay, Myers M.L, Cooper L.B –** mechanical and chemical retention of laboratory composite to metal surface ; Journal of Prosthetic dentistry1988;Vol 59;131-137.
6. **John W Mclean -** Dental ceramics proceedings of the first international symposium on ceramics; Quintessence publishing.
7. **J Robert Kelly, D Med SC, Ichio Nishimura -** Ceramics in dentistry Historical roots and current perspectives; JPD 1996; vol 75;18-32.

8. **Geuger Nico HJ, Snoedt P A -** an experimental porcelain repair system evaluated under controlled clinical condition; JPD 1992; vol 68; 724-727.

9. **Nowlin TP, Barghi Nazzar, Norlin B K -** Evaluation of bonding of 3 porcelain repair systems ;JPD 1981;vol 46;576-578.

10. **Shahverdi S., Canay S, Ahin E.S & Bilge. A** - Effects of different surface treatment methods on the bond strength of composite resin to porcelain. Journal of oral rehabilitation. 1998; Vol 25, 699-705.

11. **Bona AD, Anusavice K J, Hood J. A** - Effect of ceramic surface treatment on tensile bond strength to a resin cement; International journal of Prosthodontics 2002 ;Vol 15;248-253.

12. **Chung Kwok –Hung & Hawng Yen-Chang -** Bonding strength of Porcelain repair systems with various surface treatments; Journal of Prosthetic dentistry1997;Vol 78;267-274.

13. **Lacy A M, Laluz J, Watanabe LG, Dellinges M -** Effect of Porcelain surface treatment on bond to composite; Journal of Prosthetic dentistry1998;Vol 60;288-291.

14. **Suliman Abdul-haq A, Swift EJ** - Effect of surface treatment & bonding agents on bond strength of

composite resin to porcelain; Journal of Prosthetic dentistry1993;Vol72;355-359.

15. **Sarafiano A,Siemenis I -** Effectiveness of different surface treatment methods on bond strength of composite resin to porcelain; Journal of Prosthetic dentistry2008;Vol99;377-387.

16. **Miller T.H, Thayer K.E -** Introral repair of Fixed Partial dentures, Journal of Prosthetic dentistry1971;Vol 25;382-388.

17. **Welsh SL, Schwab JT -** Repair technique for porcelain fused to metal restorations. Journal of Prosthetic dentistry1977;Vol 38;61-63.

18. **Dent Robert** J - Repair of Porcelain fused to metal restorations ; Journal of Prosthetic dentistry1979;Vol 41;661-664.

19. **Highton R M, Caputo A. A,Matyas J -** Effectiveness of Porcelain repair systems; Journal of Prosthetic dentistry1979;Vol 42;292-294.

20. **Ferando Jean – Marc P,Graser Gerald N -** Tensile strength and microleakage of Porcelain repair materials ; Journal of Prosthetic dentistry1983;Vol 50;44-50.

21. **Meirs J.C Jensen M.E** –Effects of surface treatments on bond strength of etched metal retainers Journal of Prosthetic dentistry1971;Vol 53; 185-90.

22. **Naegali D.G Duke E.S, Schwartz R., and Norling B.K –** Adhesive bonding of composite casting alloy Journal of Prosthetic dentistry1988;Vol60;279-283.

23. **Nicholls J.I-** Tensile bond strength of composite to porcelain veeneer Journal of Prosthetic dentistry1988;Vol60; 443-237.

24. **Bailey J H -** Porcelain to composite bond strength using 4 organosilane material; Journal of Prosthetic dentistry 1989; Vol 61;174-177.

25. **Diaz A.M Schneider R.L –** Bond strength of intraoral porcelain repair materials Journal of Prosthetic dentistry1989; Vol61;305-309.

26. **Beck D.A, Janus C.E, Douglas H.B**. - Shear bond strength of composite resin porcelain repair material bonded to metal and porcelain Journal of Prosthetic dentistry1990;Vol64;529-533.

27. **Creugers Nico H.J, Snoek P.A-** An experimental porcelain repair system evaluated under controlled clinical conditions. Journal of Prosthetic dentistry1992;Vol68;724-727.

28. **Thurmond J.W., Barkmeier W.W -** Effects of porcelain surface treatments on bond strengths of composite resin bonded to porcelain. Journal of prosthetic dentistry1994; Vol 72;355-359.

29. **Maschio Aida, Tohru Hayakawa** - Adhesion of composite to porcelain with variour surface treatments, Journal of Prosthetic dentistry1995; Vol73;464-470.

30. **Kupiec K.A, Wuertz K.M –** Evaluation of porcelain surface treatments and agents for composite to porcelain repair Journal of Prosthetic dentistry1996;Vol76;119-124.

31. **Stefonos G. Kourtis** - Bond strength of rein to metal bonding systems Journal of Prosthetic dentistry1997;Vol78;136-145.

32. **Charles Habib, Haralambos Petridis, Hiroshi Hirayana**-Shear bond strength of technique for bonding esthetic veneers to metal Journal of Prosthetic dentistry1999;Vol82;608-61.

33. **Hiedo Matusumara, Saiji Shimoe, Kiyoshi Nagano -** Effect of nobel metal conditioners on bonding between prosthetic composite material and silver- palladium-copper- gold-alloy Journal of Prosthetic dentistry 1999;Vol81;710-714.

34. **Tulunoglu I.F and Beydemir B –** Resin shear bond strength to porcelain and a base metal alloy using two polymerization schemes Journal of Prosthetic dentistry2000;Vol83;181-186.

35. **James S. Knight, Dan Sneed, Michael, Wilson** - Strengths of composite bonded to base metal alloy using dentin bonding systems. Journal of Prosthetic dentistry2000;Vol83;149-153.

36. **Susanne Szep, Thomas Gerhard, Hans Werner** - Invitro dentinal surface reaction of 9.5% buffered hydrofluoric acid in repair of ceramic restorations; a scanning electron microscopic investigation. Journal of Prosthetic dentistry 2000; Vol83;668-674.

37. **Haselton D.R Diaz, Arnold A.M**. - Shear bonding strengths of 2 intraoral porcelain repair systems to porcelain or metal substructures. Journal of Prosthetic dentistry 2001; Vol 86;526-531.

38. **Ozcen M& Niedermeier W. -** Clinical study on the reasons for and location of failure of metal- ceramic and survival of repairs. international journal of prosthodontics 2002; Vol15;299-303.

39. **Jochen D. G. and Caputo A.A -** Composite resin repair of porcelain denture teeth. Journal of Prosthetic dentistry 1977; Vol 38;673-679.

40. **Kim BO- Kyoung, Bae, H,Eun- Kyung -** The influence of ceramic surface treatments on tensile bond strength of composite resin to all- ceramic coping materials, Journal of Prosthetic dentistry2005;Vol94;357-361.

41. **Gaia TS, Ozcan M, -** Repair bond strength of resin composite to Alumina reinforced Feldspathic ceramic; International journal of Prosthodontics 2006;Vol 19; 400-40.

42. **Pascal Magne, Domenico Cascione** - Influence of post-etching and cleaning and connecting porcelain on the microtensile bond strength of composite resin to feldspathic porcelain; Journal of Prosthetic dentistry2006;Vol96;354-36.

43. **Saadet Saglam Atsu,Mehmet A. Kilicarslan –** Effect of zirconium- oxide ceramic surface treatments on the bond strength to adhesive resin. Journal of Prosthetic dentistry 2006; Vol 95;430-436.

44. **Boonlert Kukiattrakoon, Kewalin Thammasitboon -** The effect of different etching times of acidulated phosphate fluoride gel on the shear bond strength of high

–leucite ceramics bonded to composite resin. Journal of Prosthetic dentistry2007;Vol98;17-23.

45. **Yalcin Ciftci, Senay Canay, Nur Hersek** - Shear bond strength evaluation of different veneering systems on ni-cr alloys journal of prosthodontics 2007Vol 16; 31-36.

46. **Lisa A. Knobloch, David Gailey, Sheren, William, Jhonston** - Bond strengths of two-step self-etch adhesive systems, Journal of Prosthetic dentistry2007;Vol97; 216-222.

47. **Parvizi S, Keshvad A, Hooshmand** – Effect of surface acid etching on the biaxial flexural strength of two hot-pressed glass ceramics.journal of prosthodontics 2008; Vol 17;415-419.

48. **Sosan Mir M. R** - The influence of ceramic surface treatments on the micro-shear bond strength of composite resin to IPS 2.journal of prosthodontics 2008;Vol17; 409-414.

49. **Hercules Jorge Almilhatti, Teresinha Giampaolo, Carlos Eduardo** - Adhesive bonding of resin composite to various ni-cr alloy surfaces using different metal conditioners and a surface modification system. journal of prosthodontics 2009;Vol18;663-669.

50. **Petra Schmage, Filiaz Yalcin Cakir, Ibrahim Nergiz** - Effect of surface conditioning on the retentive bond strengths of fiber-reinforced composite posts. Journal of Prosthetic dentistry2009;Vol 1032; 368-377.

51. **Nadia Z.Fahmy, Cherif, Mohsen** - Assessment of an indirect metal ceramic repair system. journal of prosthodontics 2010;Vol19;25-32.

52. **Ellias E. Sajjan G** - Effect of bleaching on microleakage of resincomposite restorations in non-vital teeth: An in-vitro study, endodontology 2002, Vol 14; 10- 16.

53. **John M. Powers. Ronald .L,Sakaguchi -** Craigs restorative dental materials; 12th edition.

54. **Anusauvice -** Philips science of dental materials 11th edition.

55. **Claudio Hideki Kuboi; Marcia Carneiro Valerai; Ana Paula Martins Gomesi** -The effect of endodontic materials on the optical density of dyes used in marginal leakage studies Brazilian Oral Research Jan./Mar. 2008;Vol 22;184-186.