A COMPARATIVE STUDY OF SHEAR BOND STRENGTH OF REPAIRED FUSED METAL RESTORATIONS AND INTERFACE ADAPTATION USING 3 DIFFERENT COMMERCIALY AVAILABLE REPAIR MATERIALS.

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ABSTRACT

BACKGROUND

The fracture of Porcelain Fused Metal restorations is one of the common clinical situation that occurs in routine clinical practice. Repair of fractured metal ceramic restoration can be done to reestablish the function and the aesthetics of restoration. The clinical success of ceramic repair is almost entirely dependent on the integrity of the bond between the ceramic-metal substrate and composite resin.

Aim---To evaluate the shear bond strength of repaired porcelain fused metal restorations by using different types of commercially available composite restorative materials. To assess the closer adaptation of composite and the ceramic at the fracture interface.

MATERIALS AND METHODS

The study was conducted on 43 test samples with 10 samples in control group and 11 samples in each of the three test groups (Ivoclar, 3M, Dentsply). Out of 11 samples in each test group, 10 samples were tested for shear bond strength using Lloyd’s Universal Testing Machine (Floor type) and 1 sample was tested for bonding interface adaptation.

RESULTS

Results obtained shows that the shear bond strength exhibited a mean value of 24.08 for group A, 9.14 for group B, 8.24 for group C and 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). Bonding interface adaptation was closer for Ivoclar composite restorative material than other materials.

CONCLUSION

The result of the study shows that Ivoclar composite restorative material could provide better bond strength and bonding interface adaptation as compared to other repair materials. However, further longitudinal studies under conditions simulating the oral environment are needed to prove the success and longevity of ideal composite repair material.

KEYWORDS

Composite Resin, Shear Bond Strength, Ceramic Restoration.


INTRODUCTION

Aesthetics is a demanding factor when the restoration in the missing anterior aesthetic zone is considered. 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 aesthetic 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.

Dr. Charles Land introduced one of the earliest forms of ceramic crowns in 1903. Then the first metal ceramic crown was described by Brecker in 1956. Since then various types of metal ceramic restorations have been developed with advancements been 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, aesthetics and versatility to be used for both single crown and fixed partial denture. Though ceramic materials provide excellent restorative service over the years, ceramic fracture do occur intraorally at a prevalence ranged between 5-10% over years of use.

Clinically, ceramic 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.

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. Repair may be indicated in such occasions to re-establish the function and the aesthetics of restoration by using various repair techniques.
materials. Composite resins has become the material of choice for its mode of cost, excellent aesthetics, reparability in mouth and ease of manipulation.4,5 The clinical success of ceramic repair depends on the integrity of the bond between the ceramic metal substrate and composite resin. Studies have revealed that the bond strength of composite resin and metal substrate is affected by the type of composite material, surface preparation and the type of bonding agent.1,6,7,8

Intraoral repair of fractured porcelain relies on the survival of the repair material being used. Large particle composite resin or hybrid resins at ceramic interface results in higher bond strength than those of micro-filled composites.1,9 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.1,6,7,8,10

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.1,6,7,8 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.6

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.

MATERIALS AND METHODS

The study was categorized based on the different types of commercial composite restorative materials used. The study sample was divided into four groups with 10 specimens in control group and 11 specimens in each test group, a total of 43 specimens were prepared. Group A: Control group for porcelain fused metal disc; Group B: Repaired using Ivoclar composite resin; Group C: Repaired using 3M composite resin; Group D: Repaired using Dentsply composite resin. A split circular steel die was machined in such a way that it consists of three separate parts mounted one above the other, and locked to produce the required samples (Fig. 1).

Preparation of the Resin Patterns

The metal die was lubricated with petroleum jelly and used for preparation of resin patterns; 43 disc shaped resin patterns of dimensions 1 cm and 2 mm thickness were prepared using autopolymerising acrylic resin (Hilflex). A 2.5 mm diameter sprue wax (Bego, Germany) was used and a ring less casting technique was employed. Six acrylic resin patterns were arranged in a circular pattern, separated by 3 mm on the crucible base and 3 mm from the wall of the casting ring. Surfactant were applied to the patterns and left to air dry. A phosphate bonded investment (Deguvest, Germany) was mixed with silica sol in the proportion of 150 gm of powder to 35 mL of liquid according to manufacturer’s instruction using a vacuum mixer (Bego, Germany).

The investment was allowed to set for one hour and burnout of resin patterns was done using a programmed preheating technique (Bego, Germany), i.e. the ring was kept in the room temperature and was heated to 9500C at the rate of 80C/min and held for 30 mins. at 9500C. Casting was done in induction casting machine (Bego, Germany) with Nickel chromium alloy (Heranium, Germany). The same procedure was carried to prepare for all the specimens. The metal samples were sandblasted and steam-cleaned for addition of ceramic. Out of 43 samples 10 samples were allotted for control group and upper surfaces were fully veneered with porcelain (Dentsply), whereas in the other 33 test samples only one-half of the upper surface is veneered by porcelain of 2 mm thickness and the other half of the surface is kept free (Vita Vacumat 100).

Degassing was done by placing the metal disc directly at 1200ºF (650ºC) and elevating the temperature at the rate of 15ºF (31ºC) per minute till 1925ºF (1050ºC) is reached for 15 minutes. After degassing, the metal discs were cooled in open air. Opaque porcelain is applied to a thickness of 0.5 mm and dried on a hot plate 700ºF (370ºC) for 20 minutes, then preheated to 1200ºF (650ºC) and fired at 1750ºF (950ºC) in partial vacuum (720 mmHg). Similar firing procedure is followed for body porcelain of 1.5 mm thickness. After reaching 1750ºF, the vacuum was released and the metal discs were allowed to air fire an additional minute at 1750ºF (950ºC). Before glazing, the metal discs were properly finished to attain correct thickness. A total of 43 porcelain fused discs of uniform thickness were made.

After embedding in the acrylic blocks, sandblasting with 50 mm Al2O3 for 30 seconds under 4 psi pressure was used for etching the porcelain and the metal surfaces of the test samples using microetcher. Then the specimens were cleaned with stream of water and were dried thoroughly with oil free compressed air. After the satisfactory preparation, samples were subjected to application of silane coupling agent (Silane Ivoclar Vivadent) light cure opaque and bonding agent (Helibond) prior to the addition of composite resin, both in the metal and ceramic surface as per manufacturer’s instructions.

Three different commercially available composite restorative materials (Te-Ecom plus (Group B), Z-100 TM Restorative (Group C), Spectrum (Group D) were added over the unveenered surface of the metal disc for all samples and polymerized (3M Unitek, Germany). Polishing with Shofu composite finishing and polishing kit (Japan) was done. Thermocycling was performed, in this procedure the samples were exposed to temperatures of approximately 5ºC and 55ºC alternatively with an immersion time of 10 seconds in each complete one cycle. In such a way, 500 cycles were completed and then samples were subjected to testing for shear bond strength. 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 1 mm/minute (Fig 2). Force was applied with a 50 kg compression load cell. The maximum load required to fracture a sample divided by the bonded area was recorded as the shear strength (MPa).

Dye penetration test was used to assess the bonding interface adaptation. Rate and action of dyes depends on condition of the surface material and interior discontinuity.11,12 From each group (Ivoclar, 3M, Dentsply) 1 sample was immersed in 0.1% basic fushcin and kept in vacuum flask at 37ºC for 24 hrs. After exposure to dye, the samples were rinsed in running water to remove dye from the external surface and 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.

**Statistical Analysis**

The data were then analysed 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. The test of significance for the mean obtained from four groups.

**RESULTS**

Results obtained shows the basic data of the shear bond strength exhibited a mean value of 24.08 for control group (Group A), 9.14 for group B, 8.24 for group C and 6.27 for group D (Table 1 and Graph 1). Maximum value of shear bond strength of composite restorative material with porcelain and the metal substructure was obtained with group B (Ivoclar) followed by group C (3M) and group D (Dentsply). However, none of the composite restorative material could obtain the shear bond strength comparable to control group.

Intergroup comparisons of shear bond strength using Tukey HSD test of multiple comparisons indicated that group B has better strength when compared with other two test groups - Group C and Group D. The result does not support the null hypothesis. The dye penetrated test samples assessed by video measurement system showed that Ivoclar composite material have closer bonding interface adaptation to metal and ceramic interfaces than 3M and Dentsply material (Fig. 3 and Fig. 4).

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\text{Group} & \text{Mean (MPa)} & \text{SD} \\
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\text{Group A} & 24.08 & 0.38 \\
\text{Group B} & 9.14 & 0.46 \\
\text{Group C} & 8.24 & 0.42 \\
\text{Group D} & 6.27 & 0.40 \\
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*Table 1: Shear Bond Strength (MPa) of the Four Groups*

Values are expressed in mean and standard deviation using one way ANOVA.

**DISCUSSION AND CONCLUSION**

Repair of fractured porcelain restoration depends on mode of fracture. If the porcelain fracture is mild-to-moderate, repair can be attempted introrally instead of replacing the entire restoration. Various technique have been advocated for repairing porcelain fused metal restorations such as over casting, pin retained casting, cyanoacrylate, acrylic resin material, but the results of these earlier repairs were unsatisfactory because of aesthetic and mechanical limitations. Porcelain can also be etched with hydrofluoric acid, phosphoric acid and Acidulated Phosphate Fluoride to facilitate microchemical retention of composite resin.6,13

An intraoral repair system has the advantage of chair-side application and easy to execute.14,15,16,17 The most often used for repair is hydrofluoric acid, but causes severe hazards to human tissue resulting in need for more reasonable repair alternatives.6 One easy method for increasing the surface area for bonding and decreasing the surface tension is by direct sand blasting of the tooth surface with intraoral device.18

M. Ozacan in a review revealed that the most effective surface treatment is combinations of mechanical roughening with Al2O3 followed by chemical etching with hydrofluoric acid.19,20 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 Al2O3 abrasion or a combination of both chemical and mechanical roughening.21,22,23,24 Bailey J.H. demonstrated the benefit of using vinyl silane as an organofunctional coupler between the polymer and inorganic substances in promoting the quality of the bond. Presently, several porcelain system which rely on chemical interactions (Silane coupling) which are commercially available.7, 25,26

Silane coupling agent (Mixture of ethanol, water and 1% 3-Methacryloxypropyltrimethoxysilane) was applied to the ceramic surface. Silane was applied only on ceramic surface because Ozacan in his review stated that organo silanes did not bond to the metal surface as they had with the ceramic.19,27 Then opaque resin for the metal followed by bonding agent, micro-hybrid composite resins of three different types (Ivoclar, 3M, Dentsply) were added. For the polymerization, the photo initiator (camphorquinone) is exposed to light at wavelength of 468 nm.

For repair purposes, use of the hybrid composite resins was advised. Microfilled composites with smaller particles scatter more light than the micro-hybrid composites.6 Longer exposure time is needed to obtain adequate polymerization.28
In this study, micro-hybrid composite resin was used 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. 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. The sectioned samples of each test groups are immersed in 0.1% basic fuchsirn about 24 hrs. at 37°C and studied with video measurement system at the fracture interface.

Recent studies also demonstrated that combination of the abrasive action and adhesive with separate silane treatment modalities had a synergistic influence on shear bond strength of the repair of resin composite.

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. 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. Before making an attempt to repair, 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.

Ceramic material provides 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 is composite resins. Ivoclar composite repair material shows higher bond strength values than 3M and Dentsply composite restorative materials. Bonding interface adaptation was closer for Ivoclar composite restorative material than other materials. However, further longitudinal studies under conditions simulating the oral environment are needed to prove the success and longevity of ideal composite repair material.

REFERENCES


