Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 4 Issue 1 Jan-March 2018

Review Article

AS GOOD AS NEW: REPAIR OF FRACTURED PORCELAIN FUSED TO METAL RESTORATIONS

Nazish Baig[1], Nimisha Barve[2] , Babita Yeshwante[3], Vivekanand Jadhav[4], Prasad Adhapure[5], Krishna Gorde[6]

[1] Professor and PG Guide, Department of Prosthodontics, CSMSS Dental College and Hospital, Aurangabad
[2,6] PG Student, Department of Prosthodontics, CSMSS Dental College and Hospital, Aurangabad
[3]Professor and HOD, Department of Prosthodontics, CSMSS Dental College and Hospital, Aurangabad.
[4] Reader and PG guide, Department of Prosthodontics, CSMSS Dental College and Hospital, Aurangabad
[5]Reader, Department of Prosthodontics, CSMSS Dental College and Hospital, Aurangabad.

A R T I C L E I N F O

Keywords:
Ceramics, Repair, silane coupling agent, indirect technique, direct technique, surface conditioning

A B S T R A C T

Statement of problem: Metal ceramic restorations continue to be widely used in dental practice, as they combine esthetics with superior mechanical properties. Unfortunately they are prone to fracture due to their brittle nature. **Purpose:** Direct intraoral repair of fractured porcelain traditionally relied on mechanical roughening of the fractured surface, followed by application of a silane coupling agent to enhance the resin-to-porcelain bond. The primary advantages of using composites for repair are less chair time, lower cost, and ease of use. Indirect repair techniques that use porcelain require clinical and laboratory procedures but are advantageous because of the esthetic ability of porcelain to match the remaining ceramic units. This review article describes the repair of fractured porcelain fused to metal restorations. **Conclusion**: Shear bond strength studies using direct as well as indirect repair methods show promising results. However some improvements in the bonding techniques are still needed.

INTRODUCTION

Metal-ceramic restorations are still considered a good option for oral rehabilitation 3 due to their mechanical strength ,despite the development and growing use of all ceramic.1,2 Their mechanical properties allow for the fabrication of restorations with greater rigidity and less thickness.4

Unfortunately, metal-ceramic restorations have the tendency to fracture. 1 Although fractures of such restorations do not necessarily mean failure of the restoration, they pose an aesthetic and functional dilemma to both the patient and the clinician. 5 Porcelain failures have been reported as the second greatest cause for the replacement of restorations after dental caries.6 The causes of such fractures are varied, and include impact and fatigue load, occlusal forces, incompatible thermal expansion coeffcients between the ceramic and metal substructure, use of metal with low elastic modulus, seating force during trial insertion or cementation, improper design, micro defects within the material, and trauma.5,7

Ideally, replacing the broken prosthesis is the best treatment, but this may not be within the patient's financial means. This becomes more costly with long-span prostheses. Moreover, it may be desirable to repair the broken prostheses, rather than removing and possibly destroying restorations underneath and damaging the abutment teeth.7,8Factors such as

* Corresponding author***: Nimisha Barve ,PG student, Dept Of Prosthodontics crown and bridge and impantology ,CSMSS dental college and hospital,Kanchanwadi, Aurangabad-Ph no.:9890200639 Email: nimishabarve.1110@gmail.com***

elevated cost, possible trauma to the restored tooth, lack of time, and difficulty of removing the restorations may occasionally delay the replacement of a fractured metal-ceramic restoration.9 Thus, when a fractured restoration continues to fulfil the requirements for preserving dental-periodontal health and replacement is not feasible for some reason, repair may be indicated.3, 9,10

Traditionally, repair techniques may be classified into two types: the direct method and the indirect method. Direct repairs include techniques that use light-cured composite resin applied directly to the fractured restoration1,3,9 and indirect repairs include those that use ceramic prepared in the laboratory and bonded to the fractured restoration.11

The earlier repair systems generally used two component silane coupling agents (silane and acid) designed to chemically bond composite to the silica (SiO2) component of ceramic, but had low shear bond strength. The recently introduced repair systems contain 10 methacryloyloxydecyl dihydrogen phosphate (MDP), which recommends physical alteration of ceramic and metal substrates in conjunction with chemical agents such as metal primer, ceramic primer and improved silane coupling agents to promote adhesion of resin to fractured metal ceramic restorations.12

In general, conditioning of dental material surfaces is the treatment by which the critical surface energy will be increased. Treatments may be used that enhance chemical adhesion, such as salinization and the application of adhesive primers. In addition, these may also be the treatments that promote micromechanical retention, such as airborne-particle abrasion with aluminium oxide, roughening with a diamond rotary cutting instrument, and etching with hydrofluoric acid, phosphoric acid, or with acidulated phosphate fluoride.13,14,15,16 Finally, treatments that enhance mechanical retention as well as chemical adhesion may also be considered, such as the deposition of silica by conventional airborne-particle abrasion or by the use of specific equipment and tin electroplating.17,18,19,20

METHODS

This review is based on a literature survey in which the PubMed data base and other literature sources have been utilized. The purpose of this article is to throw some light on repair methods related to porcelain fused to metal restorations and present the underlying chemistry so as to help the dentist operate in a better way when situation permits.

RESULTS

DENTAL CERAMICS

In clinical conditions, the dentist should be aware of which ceramics the fractured crown has been manufactured. Recently numerous new dental ceramic materials have been introduced, like high-aluminium trioxide (alumina) ceramics, leucite reinforced feldspathic ceramics, castable glass-ceramics, and novel machining and CAD/CAM ceramic systems

SURFACE CONDITIONING

The chemical bonds between ceramic and resin composite should be durable and reliable.

This is because of the extensive use of resin composites, resin-bonded restorations and porcelain repair system kits.

The bond between ceramic surface and resin composite can be created via:

i) micro-mechanical bonding by grit-blasting or acid etching with HF and

ii) silane coupling agent

For a successful bonding (luting) cement some requirements are:

i) adequate micromechanical retention, when clinical adhesion is less

ii) adequate wetting of the substrate by the bonding agent

(iii) resistance to fatigue, stress, erosion, and stress relief 21,22,23

CHEMISTRY OF SILANE COUPLING AGENTS

Organosilanes are synthesized from SiO2, silica (silicon dioxide) is one of the most abundant materials in the earth. Silica is reduced to silicon which reacts with hydrogen chloride to yield trichlorosilane, HSiCl3. Then, trichlorosilane reacts with alkene and finally followed by alcoholysis, i.e., reaction with alcohol, to form the functional silanes :

$SiO_2 + C \rightarrow Si + CO_2$ (1)

$Si + 3HCL \longrightarrow$ Cu catalyst $HSiCl_3 + H_2$ (2)

$HSiCl_3 + LCH = CH_2 \longrightarrow$ Pt catalyst $LCH_2CH_2SiCl_3$ (3)

$LCH_2CH_2SiCl_3 + 3ROH \rightarrow LCH_2CH_2Si(OR)3 + 3HCl$ (4) 24

A silane coupling agent, which is a trialkoxysilane, contains two functional groups at the ends of its molecular back bone, and which connect an unpolymerized resin matrix and an inorganic substrate (surface). Organofunctional trialkoxy silanes, silane esters, of the general formula R-Y-SiX3, where R' is a non-hydrolysable organic group, Y a linker (usually a propylene link) and X a hydrolysable group.25

At ambient temperature, silane is activated or hydrolysed by acid (acetic acid) to form silanol (SiOH) before they can bond to the inorganic substrate. The adhesion strength of silane varies with different materials. 26

There are the two important steps of resin substrate bonding formation with silane coupling agents:

(1) silane and substrate bond formation which is activated by acid,

(2) resin and silane bond formation which is polymerised by light curing.26

Silane is activated by acid to form silanol groups which react with the substrate surface hydroxyl (OH) groups by a condensation reaction (Si-OH + HO substrate⇒Si-O substrate) when it is applied onto a surface treated, e.g. a silica coated substrate. The reaction between the organofunctional groups of silane (with a C-C bond), and functional groups of the resin monomers containing C-C bond is induced by the reactive free radicals generated by photo-activation of initiator components in the resin matrix. As a result, resin composite and the substrate surface are connected by the silane coupling agent.27

Usually for intraoral repair or for the commonly washed off etchable ceramic surfaces after chemical etching, the exposed ceramic surface is hydrated from the surface adsorbed water. A major problem in chair-side silanization is to remove the excess surface adsorbed water.

COMMERCIAL SILANES

The most commonly used silane in dentistry is 3-methacryloxypropyltrimethoxysilane (MPS).

VARIOUS SURFACE TREATMENTS

GRIT BLASTING

Grit-blasting cleans any greasy substances from ceramic surfaces and creates micromechanical bonding.28 However microabrasion has been shown to cause casting distortion (plastic deformation), affecting the quality of fit. Possible care for microabrasion use include substituting techniques that require less microabrasion , the selection of a particle with less mass, increased distance from the handpiece to the sample, and shorter exposure times. Using a bur for micromechanical bonding is not reliable.28

These findings are in agreement with the previous studies 29,30 who reported that higher bond strengths of intraoral repair systems to ceramic and metal were achieved with air abrasion than the roughening with diamond bur. However, these results are in disagreement with Jochen and Caputo 31 and Suliman et al. 1993,who stated that higher bond strength of intraoral repair systems were obtained with roughening with diamond bur and etching with hydrofluoric acid than air abrasion alone.

CHEMICAL TREATMENTS

Etching generates a micromechanically retentive surface, but also promotes hydroxyl group formation on the ceramic surface . HF can be used for dissolution of the ceramic glass phase surface by reacting with silicon dioxide.32 The chemical reaction depends on the breaking of the siloxane bonds in ≡Si-O-Si≡ network structure. The main factors influencing reaction rate include temperature, composition and concentration of reactive species in HF acid, and also the structure of porcelain . However HF is hazardous and too corrosive hence other substitutes like APF gels and various concentrations of phosphoric acid are used .33

PYROCHEMICAL SILICA COATING

Pyrochemical means relating to or designating chemical activity at elevated temperature. In this case the silica coating is done by passing coating solution through a special flame. The Silicoater MD and Siloc systems are based on a colloidal silica and chromiumtrioxide application at high temperature, 320 C .34 When the silica-coated surface has cooled down to room temperature, it is then silanized with a silane coupling agent .After that an opaquer is light-cured and then the veneering resin composite is built on.35,36

TRIBOCHEMICAL SIICACOATING:

Tribochemical silica coating implies the chemical reaction which is caused by rubbing the silica particles on the metal or ceramic substrates. Example of tribochemical silica coating is the cojet intraoral repair system.The first step here is to coat the metal or ceramic substrate with the cojet sand (silica coated aluminium oxide particles).After that silanization and further applications of opaquer and veneering resins are done.37

INDIRECT TECHNIQUE OF CERAMIC REPAIR:

Indirect repair techniques include the following:

(1) fabrication of a pin onlay with a porcelain veneer cemented to the labial surface

(2) fabrication of a pin-retained casting with a fused porcelain veneer and

(3) fabrication of a new ‘‘overlay’’ metal-ceramic crown.

The fractured abutment is evaluated clinically and radiographically to ensure adequate metal substructure to prepare the framework for an overlay metal-ceramic casting. All remaining facial and lingual ceramic is removed by use of a diamond rotary cutting instrument under copious irrigation. Care is taken interproximally to avoid chipping the adjacent ceramic and the connector area of the original restoration. A chamfer finish line is created on the lingual aspect of the original crown, in the cervical area, and the metal along the facial chamfer was made thin or removed to simplify finishing and to prevent a cement line. All the “overlay” crowns are fabricated with suficient thickness (0.2 mm to 0.3 mm) to ensure adequate strength and rigidity. The completed metal-ceramic crowns are luted using resin luting agent.4,11

DIRECT TECHNIQUE OF CERAMIC REPAIR:

Here the fractured abutment is examined and reason for fracture is evaluated.A specific protocol regarding the method and the material used for direct ceramic repair cannot be given. However various repair systems are available which use a silane coupling, a bonding agent ,an opaque and composite resin. These systems have been combined with a prior surface treatment. 3

Results obtained by using both the above techniques are acceptable according to various studies. However according to Aristidis A. Galiatsatos the indirect method may be more predictable than the direct-repair method using composites, especially for situations in which a large portion of ceramic material is missing.11

DISCUSSION

As introduced above fracture of porcelain may not always be considered as a failure of the treatment. Reason for the fracture must be detected, analysed and handled prior to restoring the fracture with composite resin.

According to some studies the silane coupling agent was effective in establishing a strong and durable bond between composite and dental porcelain. Silane coupling agents used in conjunction with acid-etching of porcelain surfaces may create a bond stronger than a cohesive strength of the porcelain. The use of a fluoroalkylethyl silane in dental ceramics has been found to reduce stress-corrosion at the bonding interface. A study investigating the composite resin repair of porcelain using different bonding system materials inferred that the shear bond strength of composite resin to porcelain was significantly higher for porcelain bonded surfaces using a dentin bonding agent than that of other materials tested. 38

The APF gels of 1.23% can be substituted for 9.5% HF gels to etch porcelain before bonding of composite, but the lower concentration of HF may require prolonged etching.

According to Ji young yoo et al and Santos et al the cojet system of ceramic repair obtained a good bond strength and was more beneficial when the repair surface consisted of a metal substrate. The other repair systems were better used when the repair surface is a porcelain.3,39

Ashish Kalra et al conducted a study with the objective being to evaluate the shear bond strength of two intraoral porcelain repair systems. They concluded that prior mechanical alteration is beneficial for a better bond strength. Also 40% phosphoric acid can be used instead of HF for etching the metal or ceramic repair surface12

Mutlu Ozcan et al inferred that all the surface conditioning methods namely treatment with HF and air abrasion followed by salinization did not differ from each other significantly. Also they inferred that use of two layers of fiber reinforced composite between the framework of crown and repair composite can be benefical.10

R C prat et al suggested that Porcelain repair products are significantly affected by aging. Of the products evaluated, 3M's Porcelain repair kit produced the strongest shear bond after 3 months. Also according to Mutlu ozcan et al the repair showed significant degradation with long term thermal ageing. However the Cojet system showed better bond strength than the other systems even after ageing procedure. 40

Some studies inferred that the presence of porcelain autoglaze significantly decreased the bond strengths of the other systems. Nonglazed surfaces provided variable results over time.

The veneering composite used also contributes to the better bond strength. Some studies have shown that fractures could be minimized if a (submicron) hybrid composite resin is used. 41

An in vitro study has been carried out on the effect of contamination on etched and silanized porcelain surfaces and the shear bond strength of dual-cured resin composite luting cement onto them. It has been concluded that in clinical work the contamination caused by saliva and latex gloves did not significantly affect the shear bond strength. However, die stone contamination had reduced the bond strength and cleaning had not restored it. Cleaning the surfaces with acetone has significantly reduced the shear bond strength under experimental conditions.

CONCLUSION

Various surface pretreatments and silanization belong to routine dental laboratory and clinical practice resulting in direct as well as indirect restorations. Shear bond strength studies show promising results. However some improvements in the bonding techniques are stil needed. The main concern is longterm resin bond hydrolytic stability . Development of new functional silane coupling agents and novel surface treatment methods to address the problem is in progress.

REFERENCES

1) Kelsey WP 3rd, Latta MA, Stanislav CM, Shaddy RS. Comparison of composite resin-to-porcelain bond strength with three adhesives. Dent Mater 2000;48:418-21.

2) Tulunoglu IF, Beydemir B. Resin shear strength to porcelain and a base metal alloy using two polymerization schemes. J Prosthet Dent 2000; 83:181-6.

3) Dos Santos GJ, Fonseca RG, Adabo GL, Dos Santos AC. Shear bond strength of metal-ceramic repair systems. J Prosthet Dent 2006;96:165–173.

4) Sced IR, McLean JW. The strength of metal/ceramic bonds with base metals containing chromium. A preliminary report. Br Dent J 1972;132: 232-4.

5) O¨ zcan M, Niedermeier W. Clinical study on the reasons for and location of failures of metal-ceramic restorations and survival of repairs. Int J Prosthodont 2002;15:299-302.

6) Latta MA, Barkmeier WW. Approaches for intraoral repair of ceramic restorations. Compend Contin Educ Dent 2000;21:635-44.

7) Hickel R, Brüshaver K, Ilie N. Repair of restorations: Criteria for decision making and clinical recommendations. Dent Materials 2013;29:28–50.

8) Jagger DC, Wilson NHF. Defective dental restorations: To repair or not to repair? Part 2: All-ceramics and porcelain fused to metal systems. Dent Update 2011;38:150–158.

9) Pameijer CH, Louw NP, Fischer D. Repairing fractured porcelain: how surface preparation affects shear force resistance. J Am Dent Assoc 1996; 127:203-9.

10) Özcan M, Van der Sleen JM, Kurunmäki H, Vallitu PK. Comparison of repair methods for ceramic-fused-to-metal crowns. J Prosthodont 2006;15:283–288.

11) Galiatsatos AA. An indirect repair technique for fractured metal-ceramic restorations: A clinical report. J Prosthet Dent 2005;93:321–323

12) Kalra, et al.: Comparison of porcelain repair systems. Contemporary Clinical Dentistry | Apr-Jun 2015 | Vol 6 | Issue 2

13) Suliman AH, Swift EJ Jr, Perdigao J. Effects of surface treatment and bonding

agents on bond strength of composite resin to porcelain. J Prosthet Dent 1993;70:118-20.

14) Sorensen JA, Engelman MJ, Torres TJ, Avera SP. Shear bond strength of composite resin to porcelain. Int J Prosthodont 1991;4:17-23.

15) Tylka DF, Stewart GP. Comparison of acidulated phosphate fluoride gel and hydrofluoric acid etchants for porcelain-composite repair. J Prosthet Dent 1994;72:121-7.

16)Llobell A, Nicholls JI, Kois JC, Daly CH. Fatigue life of porcelain repair systems. Int J Prosthodont 1992;5:205-13.

17)Taira Y, Yoshida K, Matsumura H, Atsuta M. Phosphate and thiophosphate primers for bonding prosthodontic luting materials to titanium. J Prosthet Dent 1998;79:384-8.

18)Chang JC, Koh SH, Powers JM, Duong JH. Tensile bond strengths of composites

to a gold-palladium alloy after thermal cycling. J Prosthet Dent

2002;87:271-6.

19)Schmage P, Nergiz I, Herrmann W, Ozcan M. Influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. Am J Orthod Dentofacial Orthop 2003;123:540-6.

20)Sun R, Suansuwan N, Kilpatrick N, Swain M. Characterization of tribochemically assisted bonding of composite resin to porcelain and metal. J Dent 2000;28:441-5.

21) O¨ zcan M, Pfeiffer P, Nergiz Y. A brief history and current status of metal/ceramic surface-conditioning concepts for resin bonding in dentistry. Quintessence Int. 1998;29:713–724.

22) Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: a review of the literature. J Prosthet Dent. 2003;89:268–274.

23) O¨ zcan M. Adhesion of resin composites to biomaterials in dentistry: an evaluation of surface conditioning methods. PhD Thesis, Groningen: University of Groningen; 2003.

24) Deschler U, Kleinschmit P, Panster P.3-Chloropropyltrialkoxysilanes—key intermediates for thecommercial production of organofunctionalized silanesand polysiloxanes. Angew Chem Int Ed Engl 1986;25:236–52.

25)Arkles B. Silane coupling agents: connecting across boundaries. Morrisville, Gelest; 2003.

26) Plueddemann EP. Adhesion through silane coupling agents.J Adhes 1970;2:184–201.

27) Lung CYK, Matinlinna JP. Resin bonding to silicatizedzirconia with two isocyanatosilanes and a cross-linkingsilanes. Part II: mechanistic approach. Silicon 2010;2:163 -9

28) Guggenberger R. Das Rocatec System – Haftung durch tribochemische Beschichtung. Dtsch Zahnarztl Z. 1989;44:874–876.

29) Thurmond JW, Barkmeier WW, Wilwerding TM. Effect of porcelain surface treatments on bond strengths of composite resin bonded to porcelain. J Prosthet Dent 1994;72:355 9

30) Proano P, Pfeiffer P, Nergiz I, Niedermeier W. Shear bond strength of repair resin using an intraoral tribochemical coating on ceramometal, ceramic and resin surface. J Adhes Sci Technol 1998;12:1121 3.

31) Jochen DG, Caputo AA. Composite resin repair of porcelain denture teeth. J Prosthet Dent 1977;38:673 9.

32) van Noort R. Dental Ceramics. In: van Noort R, ed. An introduction to dental materials. Hong Kong: Elsevier Science; 2002:231–246.

33) Pattanaik S, Wadkar AP. Effect of etchant variability onshear bond strength of all ceramic restorations—an in vitrostudy. J Indian Prosthodont Soc 2011;11:55–62

34) Meiners H, Herrmann R, Spitzbarth S. Zur Verbundfestigkeit des Rocatec-Systems. Dental Labor. 1990;38:185–188.

35) Silanes and other couplingagents, vol. 4. Florida: CRC Press; 2007.p. 203–4.

36)Resin/resin bonding:a new adhesive technology. J Adhes Dent 2002;4:299–308.

37) O¨ zcan M. The use of chairside silica coating for different dental applications: a clinical report. J Prosthet Dent. 2002;87:469–472.

38) E.Yassini1, K.Tabari ,Comparison of Shear Bond Strength between Composite Resin and Porcelain Using Different Bonding Systems, Journal of Dentistry, Tehran University of Medical Sciences,2005; Vol. 2, No. 1

39) Ji-Young Yoo, Hyung-In Yoon, Ji-Man Park, Eun-Jin Park. Porcelain repair - Influence of different systems and surface treatments on resin bond strength J Adv Prosthodont 2015;7:343-8

40) R. C. Pratt, J. 0. Burgess, R. S. Schwartz, J. H. Smith, Evaluation of bond strength of six porcelain repair systems,J Prosthet Dent JULY 1929 : 62 ; 1

41) Creugers, Snoek, and Kbyser the experimental porcelain repair system. J Prosthet Dent november 1992 ; 68 : 5