https://doi.org/10.5272/jimab.2017231.1456
Journal of IMAB
ISSN: 1312-773X
https://www.journal-imab-bg.org

Journal of IMAB - *Annual Proceeding (Scientific Papers).* 2017 Jan-Mar;23(1):

INFLUENCE OF SILANE HEAT TREATMENT ON THE TENSILE BOND STRENGTH BETWEEN EX-3 SYNTHETIC VENEERING PORCELAIN AND COMPOSITE RESIN USING FIVE DIFFERENT ACTIVATION TEMPERATURES.

Spartak Yanakiev[1], Bozhidar Yordanov[2], Valentin Dikov[3]
1) Medical College"Y. Filaretova", Medical University - Sofia, Bulgaria
2) Department of Prosthetic Dental Medicine, Faculty of Dental Medicine, Medical University - Sofia, Bulgaria
3) Department of Machine Elements and Non-metallic Constructions, Mechanical Engineering Faculty, Technical University - Sofia, Bulgaria.

ABSTRACT

Purpose: The purpose of the present study is to assess the effect of five different silane activation temperatures and eight activation methods on the tensile bond strength between one veneering porcelain and one composite resin material.

Material and methods: A total of 81 ceramic rods were made of EX-3 veneering ceramic (Kuraray Noritake Dental, Japan). Sintered ceramic bars were grinded with diamond disks to size 10x2x2mm ± 0,05mm. The front part of each bar was polished. After ultrasonic cleaning in distilled water the specimens were divided into nine groups. Silane was activated with air at room temperature, 38º C, 50º C, 100º C, 120º C using a custom made blow drier. In a silicone mould a composite resin Z250 (3M ESPE, St. Paul, USA) was condensed toward the bond ceramic surface. A total of 81 specimens approximately 2,0 cm long were prepared for tensile bond testing. One way ANOVA, followed by Bonferroni and Games-Howell tests were used for statistical analysis.

Results: The lowest tensile bond strength was observed in the control group (3,51 MPa). Group 2 yielded the highest bond strength among all groups (19,54 MPa). Silane heat treatment enhanced the bond strength for all treatment methods. Within the polished specimens the highest bond strength was yielded with warm air at 120º C (11,31 MPa).

Conclusion: The most effective method for bonding Z250 composite resin to EX-3 veneering ceramic includes HF etching, silane and adhesive resin. The most effective heat treatment method for bonding is hot air at 120º C.

Keywords: silane, silane coupling agent, heat treatment, tensile bond strength, composite, ceramic

INTRODUCTION

Porcelain fused to metal (PFM) restorations are frequently used to restore both anterior and posterior teeth, providing high strength, durability and satisfying aesthetic results [1, 2]. Despite the progress in modern dental materials one of the main reasons for clinical failure of PFM crowns and bridges is veneering porcelain fracture. Depending on clinical trial periods authors report that porcelain fracture occurs in up to 19,4% of the cases for 3 to 11 years follow-up periods [2, 3, 4, 5]. This include even minor chippings, that should not be classified as failures. The clinical significance of a porcelain fracture should be assessed according to the size of the fractured fragment and the negative effect on function and aesthetics. Thus the clinician should choose either to replace the restoration, or torepair the existing one directly or indirectly.

Intraoral repair of the fractured prosthesis is often more suitable from practical point of view- it is easy to perform, cost effective and a good esthetic result could be achieved in a single visit. The material of choice to replace the missing fragment is composite resin. In order to achieve durable results several factors must be considered – causes of fracture, type of ceramic material, appropriate bonding technique etc. A number of authors have studied different bonding procedures for optimizing bond strength between porcelain and composite, including bur roughening, air-particle abrasion with Al_2O_3, etching with hydrofluoric acid (HF), silane coupling agents (silanes) and adhesive resins [6, 7, 8, 9].

The positive effect of HF on bonding composite to silica based ceramics was reported in several studies [10, 11]. On the other hand HF is potentially harmful to both the patient and the clinician if it comes in contact with skin, eyes or mucosa [12]. That's why some authors exert efforts on improving the chemical bond provided by silane coupling agents. Silane treatment with heated air flow or in oven is one of the most frequently used methods [6, 7, 8, 9, 13]. Different authors propose heating temperatures from 38 to 100º C, but a systematic approach to the effect of the different heating temperatures on the bond strength has not been conducted.

The purpose of the present study is to assess the effect of five different silane activation temperatures and eight activation methods on the tensile bond strength between one veneering porcelain and one composite resin material.

MATERIALS AND METHODS

A total of 81 specimens were made for the purpose of this study. Ceramicteststicks were fabricatedfrom EX-3 veneering porcelain using a silicone mould (EliteDouble 8 (ZhermackTechnical, BadiaPolesine, Italy). The material was pressed and condensed, carefully removed from the mould and sintered according to the manufacturer's instructions. Sintered ceramic bars were grinded with diamond disks to size 10x2x2mm ± 0,05mm. The front part of each stick was polished with a sequence of polishing instruments until glass-like surface was achieved. After polishing all ceramic specimens were ultrasonically cleaned in distilled water for five minutes and divided into nine groups. Each group received one of the following treatments:

Group 1: No further treatment (control group)

Group 2: Hydrofluoric acid etching for 120 sec. (IPS Ceramic, Ivoclar Vivadent, Schaan, Lichtenstein), ultrasonic cleaning in distilled water, followed by application of silane coupling agent (Monobond Plus, Ivoclar Vivadent, Schaan, Lichtenstein) for 60 sec. and adhesive resin (Adper™ SingleBond 2, 3M ESPE, St. Paul, USA).

Group 3: Silane for 60 sec. Silane was dried with compressed oil-free air at room temperature for 60 sec., and adhesive resin was applied

Group 4: As group 3, silane was dried with warm air (38º C)

Group 5: As group 4, but bond surface was roughened with a diamond bur (green mark)

Gropu 6: As group 3, silane was dried with warm air (50º C)

Group 7: As group 3, silane was dried with warm air (100º C)

Group 8: As group 3, silane was dried with warm air (120º C)

Group 9: Silane was applied for 60 sec., dried with warm air (38º C) for 30 sec., rinsed under tapping water for 20 sec., and dried with warm air (38º C) for another 30 sec. Then adhesive resin was applied.

A custom made blow drier, delivering constant warm air flow within the range 38º C-130º C was used in the study. After the application of the resin bonding agent each ceramic stick was placed in silicone mould and composite resin Z250 was condensed into the mould and toward the bond ceramic surface. Each specimen was light cured for 20 sec. with halogen lamp, removed from the mould and additionally light-cured for another 40 sec. A total of 81 specimens app. 2,0 cm in length were prepared for bond testing.

For tensile bond strength testing each specimen was fixed by cyanoacrylate to the jigs ofa mechanical testing machine (LMT-100, LAM Technologies, Florence, Italy) and was loaded at a speed of 1mm/min..

For the statistical analysis the level of significance was set at α=0,05. In order to asses any significant difference among the groups one way ANOVA, followed by Bonferroni test and Games-Howell tests were used.

RESULTS

Tensile bond strength values are shown in tab. 1. All data that showed extreme values were excluded from the statistical analysis. The lowest tensile bond strength was observed in the control group (3,51Mpa). Group 2 yielded the highest bond strength among all group (19,54Mpa). This is significantly different from the values obtained in all other groups. Silane heat treatment enhanced the bond strength for all treatment methods. Within the polished specimens the highest bond strength was yielded with warm air at 120º C (11,31Mpa). Group 5 showed the second best results (13,80Mpa).***

Table 1. Mean tensile bond strength in MPa (standard deviation)

Treatment method	n	$\bar{X}$	SD
Group 1	9	$3{,}51^{a}$	1,13
Group 2	9	$19{,}54^{c}$	4,82
Group 3	9	$8{,}85^{a}$	4,36
Group 4	9	$9{,}69^{bde}$	3,16
Group 5	9	$13{,}80^{bdf}$	2,49
Group 6	9	$8{,}75^{aefg}$	2,21
Group 7	9	$9{,}37^{bdg}$	3,43
Group 8	9	$11{,}31^{bdg}$	3,27
Group 9	9	$9{,}41^{bdg}$	3,69

*-Identity in letters indicates no significant statistical difference (p<0,05)

DISCUSSION

Acid etching, followed by silane application was the most effective bonding procedure in the present study. The value (19,54MPa) is close to those reported in other studies [6, 7, 14]. The role of HF in producing microretentive ceramic surface is well documented in the literature [11, 15]. In contrast to microabrasion with 50 µm Al_2O_3 or roughening with diamond bur, HF creates microporosities and undercuts, allowing the resin to penetrate and establish a strong and durable bond [10, 11]. However, hydrofluoric acid is extremely toxic and possibly very harmful if inhaled or swallowed or in cases of contamination of oral mucosa and skin [12]. The reaction between HF and the glassy matrix of ceramic leads to formation of precipitates, deposited on the substrate. They should be removed in order not worsen the strength between the resin and the ceramic material. This can be achieved easier in laboratory conditions. The disadvantages listed above urge many authors to search for methods to enhance ceramic-resin composite bond excluding HF from the clinical protocol.

Silane heat treatment is the most frequently used method to obtain strong and durable ceramic-composite bond without the use of HF. The phenomenon reported by many authors, that silane activation with hot air enhanced the tensile bond strength, was confirmed in the present study [6, 7, 8, 9]. This is evident comparing the tensile bond strength results of the heat treated groups and the control group. Nevertheless none of the heat treatment methods yielded tensile bond strength significantly identical to that of group 2. One should have in mind that due to the polishing of the ceramic surface the adhesion between the ceramic and the composite resin was based mainly on the chemical reaction between the silane coupling agent and the ceramic material. Therefore, the use of the heat activated silane in combination with microabrasion or diamond bur roughening could lead to a higher tensile bond strength. Further studies should be made.

Within the limitations of this study the only temperature used in combination with bur roughening was 38º C, resulting in the second best tensile bond strength, although the value is still significantly lower than that of the HF group. Air heated at 38º C enhanced the silane provided bond strength in another study [16].

The most effective heating temperature in this study was 120º C. As far as we know none of the authors use such a high temperature and a comparison could not be made. Although this temperature proved to be effective, it cannot exclude the use of HF when bonding Z250resin composite to EX-3 ceramic.

The other temperatures used in this study (50º C and 100º C) enhanced the tensile bond strength, but not enough to be significantly identical to the HF group. This is in contrast with the results reported by some authors [6, 7] and confirm the results reported by others [9]. Generally all authors report that heat treatment enhances bond strength but the results differ according to the materials used in the survey. Although this relation is confirmed in the present study, it is not possible to make precise correlation between the temperature and the tensile bond strength.

The treatment method used in group 9 is a modification of the method used by Hooshmand et al. [8]. We preferred lower air and water temperature in order to assess a heat treatment method which is harmless for intraoral use. According to the tensile bond strength results it was not effective enough.

CONCLUSION

Within the limitations of this study the following conclusions could be made:

1. The most effective method for bonding Z250 composite resin to EX-3 veneering ceramic includes HF etching, silane and adhesive resin.

2.Silane activation with hot air enhances the tensile bond strength in all groups.

3.The most effective heat treatment method for bonding Z250 composite resin to EX-3 veneering ceramic is hot air at 120º C

REFERENCES:

1. Ozer F, Mante FK, Chiche G, Saleh N, Takeichi T, Blatz MB. A retrospective survey on long-term survival of posterior zirconia aand porcelain-fused-to-metal crowns in private practice. *Quintessence Int.* 2014 Jan;45(1):31-8. [PubMed] [CrossRef]

2. Reitemeier B, Hänsel K, Kastner C, Weber A, Walter MH. A prospective 10-year study of metal ceramic single crowns and fixed dental prosthesis retainers in private practice settings. *J Prosthet Dent.* 2013 Mar;109(3):149-55. [PubMed] [CrossRef]

3. Sailer I, Gottnerb J, Kanelb S, Hammerle CH. Randomized controlled clinical trial of zirconia-ceramic and metal-ceramic posterior fixed dental prostheses: a 3-year follow-up. Int J Prosthodont. 2009 Nov-Dec;22(6): 553-60. [PubMed]

4. Napankangas R, Raustia A. An 18-year retrospective analysis of treatment outcomes with metal-ceramic fixed partial dentures. *Int J Prosthodont.* 2011 Jul-Aug;24(4):314-9. [PubMed]

5. Dorri M. All-ceramic tooth-supported single crowns have acceptable 5-year survival rates. *Evid Based Dent.* 2013; 14(2):47. [PubMed] [CrossRef]

6. Fabianelli A, Pollington S, Papacchini F, Goracci C, Cantoro A, Ferrari M, et al. The effect of different surface treatments on bond strength between leucite reinforced feldspathic ceramic and composite resin. *J Dent.* 2010 Jan;38(1):39-43. [PubMed] [CrossRef]

7. Shen C, Oh WS, Williams JR. Effect of post-silanization drying on the bond strength of composite to ceramic. *J Prosthet Dent.* 2004 May;91(5):453-8. [PubMed] [CrossRef]

8. Hooshmand T, van Noort R, Keshvad A. Bond durability of the resin-bonded and silane treated ceramic surface. Dent Mater. 2002 Mar; 18(2):179-88. [PubMed] [CrossRef]

9. Cotes C, de Carvalho RF, Kimpara ET, Leite FP, Ozcan M. Can heat treatment procedures of pre-hydrolyzed silane replace hydrofluoric acid in the adhesion of resin cement to feldspathic ceramic? *J Adhes Dent.* 2013 Dec;15(6):569-74. [PubMed] [CrossRef]

10. Bottino MC, Ozcan M, Coelho PG, Valandro LF, Bressiani JC, Bressiani AH. Micro-morphological changes prior to adhesive bonding: high-alumina and glassy-matrix ceramics. *Braz Oral Res.* 2008 Apr-Jun; 22(2):158-63. [PubMed] [CrossRef]

11. Della Bona A, Anusavice KJ. Microstructure, composition, and etching topography of dental ceramics. *Int J Prosthodont.* 2002 Mar-Apr;15(2): 159-67. [PubMed]

12. Anderson WJ, Anderson JR. Hydrofluoric acid burns of the hand: mechanism of injury and treatment. *J Hand Surg Am.* 1988 Jan;13(1):52-7. [PubMed] [CrossRef]

13. de Carvalho RF, Cotes C, Kimpara ET, Leite FP, Özcan M. Heat treatment of pre-hydrolyzed silane increases adhesion of phosphate monomer-based resin cement to glass ceramic. *Braz Dent J.* 2015 Jan-Feb; 26(1):44-9. [PubMed] [CrossRef]

14. Roulet JF, Söderholm KJ, Longmate J. Effects of treatment and storage conditions on ceramic/composite bond strength. *J Dent Res.* 1995 Jan;74(1):381-7. [PubMed]

15. Kukiattrakoon B, Thammasitboon K. The effect of different etching times of acidulated phosphate fluoride gel on the shear bond strength of high-leucite ceramics bonded to composite resin. *J Prosthet Dent.* 2007 Jul;98(1):17-23. [PubMed] [CrossRef]

16. Monticelli F, Toledano M, Osorio R, Ferrari M. Effect of temperature on the silane coupling agents when bonding core resin to quartz fiber posts. *Dent Mater.* 2006 Nov;22(11):1024-8. [PubMed] [CrossRef]

Please cite this article as: Yanakiev S, Yordanov B, Dikov V. Influence of silane heat treatment on the tensile bond strength betweenEX-3 syntetic veneering porcelain and composite resin using five different activation temperatures. *J of IMAB.* 2017 Jan-Mar;23(1):1456-1459. DOI: https://doi.org/10.5272/jimab.2017231.1456

Received: 22/11/2016; Published online: 08/02/2017

Address for correspondence
Assist. Prof. Spartak Yanakiev,
Medical College "Yordanka Filaretova", Sofia,
3, Yordanka Filaretova str., Sofia, Bulgaria
phone number: +359886445108.
E-mail: spartak_ianakiev@mail.bg