Influence of Different Cementation Materials and Thermocycling on the Fracture Resistance of IPS e.max Press Posterior Crowns

M Abou-Madina, K Abdelaziz

Citation

M Abou-Madina, K Abdelaziz. *Influence of Different Cementation Materials and Thermocycling on the Fracture Resistance of IPS e.max Press Posterior Crowns*. The Internet Journal of Dental Science. 2008 Volume 6 Number 2.

Abstract

Aim: To evaluate the effect of different cementation materials and thermocycling on the fracture resistance of IPS e.max Press posterior crowns.

Materials and methods: Thirty-two sound maxillary molars were subjected to a standardized preparation in order to receive IPS e.max Press (Ivoclar Vivadent) ceramic crowns. Another 16 molars were left unprepared to serve as control (Group I). Both Panavia F2.0 (Kuraray) and Relay X Unicem (3M ESPE) luting cements were used to fix the fabricated crowns (n=16 for each) to their respective prepared teeth (Groups II and III respectively). Eight specimens from each of the 3 test groups were randomly selected for further thermocycling (5000 cycles). All specimens were then vertically pressed using anatomical metal attachment affixed to the upper member of a universal testing machine and running at crosshead speed of 1mm/min. The collected data were statistically analyzed using 2-way analysis of variance (ANOVA) and Student's t-test at 5% level of significance.

Results: The load values that the restored teeth can withstand (From 907 to 986 N) was much lower than that recorded for normal teeth (1279 N) (2-way ANOVA test, $p<0.001$). No significant difference in the fracture load values was detected among the groups of restored teeth (986 MPa and 974 N for groups II and III) (Student t test, $p>0.05$). Thermocycled specimens showed lower values of fracture loads in comparison to non-thermocycled ones (Student t test, $p<0.001$).

Conclusions: Either kinds of cement materials used looks to have no effect on the fracture resistance of IPS e.max crowns to vertical loads. Thermocycling adversely affects the ability of the cemented crowns to resist the applied load. The fracture loads of the tested crowns exceeded the recorded values of normal occlusal forces.

INTRODUCTION

In spite of the amazing success of metal-ceramic crowns[1,2] their known drawbacks, such as questionable marginal esthetic and biocompatibility, were directed the attention toward the use of metal-free restorations. [34] In the last 2 decades several manufacturers had introduced new ceramic systems having the ability to overcome the hereditary brittleness and low fracture toughness of early ceramic materials.[5] These features together with excellent esthetic, biocompatibility, resistance to wear and low thermal conductivity nominated many of the current all-ceramic systems to pass the challenge expected to face when applied in the posterior region of the mouth. [6,7,8,9,10]

Heat-pressing is a process that has been developed to overcome the inhomogeneities and porosity that occur during creaming.[11,12] The first heat-press ceramic material (IPS Empress, Ivoclar –Vivadent, Schaan, Liechtenstein) is a type of leucite-reinforced glass ceramic and has a flexural strength of 182 MPa.[12] A modified version of this material (IPS Empress 2) having lithium disilicate (2 Sio_2- Li_2O) crystals could provide an average fracture strength of 350 MPa. Therefore, it was nominated not only for anterior 3 unite bridges, but also for restoration of posterior region which may include a first premolar as a pontic.[13]

An improved press ceramic material called IPS e.max Press (Ivoclar –Vivadent) was recently introduced specially for posterior and bridge applications. The new material consists of lithium disilicate pressed glass ceramic like that of IPS

Empress 2, but the properties are changed by a different firing process. (Scientific documentation, IPS e.max Press, Ivoclar –Vivadent, Schaan, Liechtenstein) Also, the framework can be veneered with a new type of sintered fluoroapatite porcelain that has nearly the same coefficient of thermal expansion as IPS e.max Press framework has. In comparison with IPS Empress 2, combining the two glass ceramic materials exhibit substantially improved physical properties and greater translucency. [14]

Albakry et al.,[15] determined the biaxial flexural strength of different pressable ceramic materials. IPS e.max Press recorded higher flexure strength values in comparison to IPS Empress and Empress 2 materials. Komine et al,[16] examined the static fracture load of three-unit IPS e.max Press frameworks and bridges. Non-veneered and veneered frameworks were also tested. The fracture strength of veneered frameworks was found to be higher than that of those without veneering. Edelhoff et al.,[17]discovered that the translucency of IPS e.max Press is so sensitive, dramatically affected by the choice of cementation material and it is better to use translucent cement underneath.

On the other hand and as a result of the inherent mechanical characteristics (brittleness, and low flexural and tensile strengths),[18] ceramic materials usually fracture at a fraction of their theoretical strength.[2] To overcome this problem, many authors believe that metal-free ceramic restorations should be bonded to the tooth with a kind of strong cements [19,20] Therefore, the purpose of this study was to address the question of whether different types of cementing media in addition to thermocycling significantly influence the fracture resistance of IPS e.max Press posterior crowns.

MATERIALS AND METHODS

TEETH SELECTION AND GROUPING

Extracted maxillary molars were collected at The Department of Oral Surgery, Mansoura University, Faculty of Dentistry. The collected molars were ultrasonically cleaned and stored in 1% chloramines B-hydrate solution for 1 week.[21] For this investigation, only 48 caries and crack-free molars with no hypoplastic defects were visually selected by the aid of x10 magnifying glass.

The selected molars were randomly divided into 3 main groups (n=16) (Table 1). In Group I, the molars were left without any kind of preparation to serve as control. Molars of the other groups were subjected to a standardized preparation to receive IPS e.max press crowns. The fabricated crowns were cemented to their respective molars using either Panavia F2.0 (PF) and Relay X Unicem (Rx) luting cements forming groups II and III. The materials used, their characters and manufacturers were listed in (Table 2).

Figure 1

Table 1: Study design

Test Groups (n=16 for each)		Test Subgroups (n=8 for each)	
Group I:(control) Unprepared molars		**Subgroup 1:**	Thermocycled
		Subgroup 2:	Non thermocycled
Group II: Prepared molars having IPS e.max crown restoration	Crowns were cemented with Panavia F2.0 (PF)	**Subgroup 1:**	Thermocycled
		Subgroup 2:	Non thermocycled
Group III: Prepared molars having IPS e.max crown restoration	Crowns were cemented with Relay X Unicem (Rx)	**Subgroup 1:**	Thermocycled
		Subgroup 2:	Non thermocycled

Figure 2

Table 2: Materials used.

Materials	Composition	Manufacturer
IPS e.max press	• Lithium silicate reinforced pressable glass ceramic	Ivoclar–Vivadent Sheen, Lecitinchtien
IPS e.max ceram	• Fluoroapatite veneering ceramic	Ivoclar–Vivadent Sheen, Lecitinchtien
Panavia F2.0	• Primer A: HEMA, 10-MDP,5-NMSA • Primer B: 5-NMSA, water, sodium benzene • Paste A: silica,dimethacrylate • Paste B: barium glass, sodium fluoride, dimethacrylate.	Kuraray, Medical Inc., Osaka, Japan
Relay X Unicem	• Powder: glass powder, silica, calcium hydroxide • Liquid: methacrylated phosphoric ester, dimthacrylate	3M ESPE St. Paul, MN

TEETH PREPARATION

All the selected molars were vertically fixed in metal rings using self-cured acrylic resin (Duracrol, Sofa-Dental, Prague, Czech republic) after coating their roots with a 0.25 mm thick layer of low viscosity silicone rubber to represent the periodontal ligament (Imprint II, 3M ESPE, Saint Paul, MN). The roots were embedded in the fixing resin 1mm away from the cervical line. Molars in groups II and III were subjected to a standardize preparation using water-cooled cross slide carbide insert running at 400 rpm on a lathe cutting machine (AB wood Machine tools LTD SGia M/C No.17531, BVC, China). The prepared teeth were adjusted to be 4 mm high with 10o occlusal taper, 1.2 mm shoulder finishing line and flat occlusal surfaces. All the prepared teeth were impressed using medium viscosity vinyl polysiloxane impression material (Imprint II, 3M ESPE, Saint Paul, MN) in custom made acrylic trays and poured in Type IV gypsum (Zeta Muffle, Acrostone, Cairo, Egypt). Both prepared and unprepared teeth were then incubated in tap water at 37±1oC for 24 h before cementing the fabricated ceramic crowns and testing the resistance of all to fracture under vertical loading.

FABRICATION OF CERAMIC CROWNS

The axial surfaces of the prepared teeth 0.5 mm from the finishing line were coated with die spacer (Tru-Fit, Co. Inc, Jersey City, NJ). Full wax-ups were made for the proposed crowns. Round wax sprues 3 mm in diameter were attached to each of the wax-ups approximately 45o on the long axis before investing in Empress 2 speed investment material (Ivoclar Vivadent, Schaan, Liechtenstein). The preheating cycle was carried out at 850oC for 60 min. The molds were then transferred to the furnace and press-filled with IPS e.max Press ingot material at 915oC for 20 min. After divesting and separation of the restoration the tooth-colored copings were veneered with IPS e.max ceram.

Fitness of the fabricated crowns was checked up on their corresponding prepared teeth. Points of interference on the intaglio surfaces were corrected under water-air cooling, using fine-grit diamond tips in high-speed angled handpiece. The intaglio surfaces of the restorations were then sandblasted (Reco Dental Corp, Wiesbaden, Germany) using 100µm sized AL_2O_3 particles at 1 bar of air pressure and etched with 8% hydrofluoric acid (Choice, Bisco Dental Corp, Itasca, IL) for 20 s before rinsing and air drying for another 30 s each.

CEMENTATION OF CROWNS AND THERMOCYCLING

Silane coating (3M ESPE, St. Paul, MN) was applied to the etched intaglio surfaces, allowed to evaporate for 3 min and air-dried for 30 s immediately before cementation. Sixteen of the constructed crowns (Group II) were cemented to their corresponding molars using Panavia F2.0 (Kuraray Medical Inc., Osaka, Japan) according to the manufacturer's instructions. Equal amounts of ED primer 2.0 A and B was mixed and applied to the dentin surface before the application of cement material. The other 16 crowns (Group III) were cemented to their respective teeth using Rely X Unicem (3M ESPE, St. Paul, MN) and no conditioning step was required for this group according to the manufacturer's instructions.

At the time of cementation, the crowns were secured in place for 1 min using finger pressure and seated under 5 kg constant load for 10 minutes[2]. Half the number of teeth in each group (n=8, subgroup 1) were subjected to thermocycling for 5000 cycle at 5 and 55?C for 60 s each, with an intermediate pause of 12 seconds,[5] while the other half was incubated (Binder Inc, Great river, NY) without thermocycling (subgroup 2) in tap water at 37±1oC. (Table 1).

TESTING THE FRACTURE RESISTANCE

Each specimen was fixed in a specially designed jig mounted to the lower member of the universal testing machine (Type 500, Lloyd instrument, England). Specimens of all groups were compressively loaded until fracture by the aid of anatomical metal attachment representing the opposing contacts and mounted to the moving member of the testing machine (Figure 1). All tests were carried out at crosshead speed of 1mm/ min and the maximum fracture load was recorded when either cracking sounds or visible cracks were noticed.

Figure 3

Figure 1. Anatomical metal attachment used to apply compressive loads to the cemented IPS e.max crowns

STATISTICAL ANALYSIS

Two-way analysis of variance (ANOVA, p=0.05)) was used to analyze the fracture load values between the three test groups to detect the possibility of differences among the two test variables (types of cement materials and thermocycling). The interaction between both variables was also of concern. Student's t-test was performed to detect which subgroup was exactly differ (p=0.05) from the others.

RESULTS

Mean fracture loads (N) and standard deviations for all test subgroups are shown in table 3. One-way ANOVA test indicated the presence of difference between the test groups. A significant interaction between the tested variables (Type of cement and thermocycling) was also evident. Test specimens of groups II and III recorded significantly lower fracture loads in comparison to those recorded for natural unprepared teeth (group I) before and after thermocycling (t-test, P=0.001). No significant differences was noticed among the fracture loads of groups II (PF) and III (RX) (P> 0.05). Thermocycling significantly deteriorate the fracture resistance of subgroups independent on the type of luting media (P<0.001).

Figure 4

Table 3: Means fracture loads (N) of different test groups before and after thermocycling.

Groups	Group I Unprepared teeth		Group II Crowns cemented with PF		Group III Crowns cemented with RX		F	P
Thermocycled	X·	±SD	X·	±SD	X·	±SD	8.1	<0.05
	1043^n	261	921*n	19	907*n	21		
Non-thermocycled	1279*m	193	986*m	23	974*m	11	13.6	<0.05

* Significantly different from the control
For each group different superscripts indicating significant difference (t-test, p<0.05)

DISCUSSION

Strength of ceramic crowns is a multifactorial property that governed by the strength properties and thickness of selected ceramic material as well as the configuration of the constructed crowns.[21] Cement's interfacial properties and the elastic modli of different components of the adhesive junction (Ceramic, cement and tooth) have also been reported to have close association with both crack initiation and propagation in dental ceramic restorations. [22,23]

In practice crown failure usually occurs under a complex type of stresses, however, this in vitro study addressed only the resistance on compression which appears to be appropriate for posterior teeth.[24] Metal-ceramic crowns were used in certain studies[25,26] to compare the performance of all-ceramic ones. However, the unprepared natural teeth looked to be the commonly nominated reference because the main restorative goal of fixed prosthodontics is not to improve the nature, but to restore the function and esthetic. [21,22,23,24]

Laboratory teeth preparation usually follows the clinically established reduction criteria for all-ceramic crowns.[25,26,27] The low angle of tapering (10o) may have caused the increased dependence of cement layer thickness on the fitness of the prosthesis. The increase in cement thickness would accordingly increase the volume of materials with lower modulus of elasticity and strength within the adhesive junction.[28] This study tried to fix this annoying variable through controlling the cement film thickness. The application of definite number of uniform coats of die spacer[19] and the use of constant value of pressure at the time of cement setting[2] did help regarding this issue.

A number of investigators[29,30,31] showed differences in the fracture resistance of cemented crowns using a wide variety of cementing media. Their results suggest that certain combinations of materials (Ceramic systems and cement) may have some beneficial effect on the value of fracture strength. In this in vitro study the fracture strength of e. max Press crowns were not affected by the type of cement used. These findings are not directly transferable to the clinical situation, but the followed testing protocol has been shown to correlate well with clinical studies assessing the performance of restorations over 5-years.[32,33]

Panavia F and Rely X Unicem both consist of multifunctional phosphoric acid dimethacrylate modified monomers, such as Bis-GMA, and inorganic fillers of fine glass and silica.[34] The current study did not discover any significant difference in the values of fracture resistance among the non-thermocycled crowns of in groups II and III, is spite of the conflict with some previously recorded data.34 It may be assumed that the ductile resin cement functions as a shock absorber so that it can distribute the force during the fracture resistance test at the tooth-cement-ceramic interfaces.[35] Certain studies[36,37] proved that the use of dentin bonding agents improve the fracture resistance of cemented crowns simply because it perfectly seals dentinal tubules and thus prevents fluid outflow from the pulp that could affect the setting of the cement material and its adaptation to the dentin surface.

Thermocycling is a way to expose materials to thermal stresses as a result of abrupt changes in temperature and to simulate aging of the retentive system of crowns.[38] Thermocycling has been found to have an adverse influence on the fracture resistance of cemented crowns. This reduction could be the result of deteriorating cement material underneath [27,38] Waltimo and Konenen[39] found that the maximum biting force in the molar region was 847 N for men and 597 N for women. Although the results of the current study cannot be directly compared with the in vivo situation, the mean load at fracture was far greater than the clinically anticipated load.

Subjecting the specimens to cycling loading could be considered in further investigation to give more information about the longevity and performance of IPS e.max crowns in situation relatively resemble the clinical situation.

CONCLUSIONS

Within the limitations of this in-vitro study the following conclusions could be deduced; there is no significant influence of the cement type, either Panavia F2.0 or Relay X Unicem, media on the fracture resistance of IPS e.max posterior crowns. Thermocycling has an adverse effect on the fracture resistance of cemented IPS e.max Press crowns.

CORRESPONDENCE TO

Dr. Khalid M Abdelaziz Dept. of Restorative Dentistry King Khalid Univ., College of Dentistry P.O. Box 3263 Abha 61471 Kingdom of Saudi Arabia Tel: + 966 7 2298981 Fax: +966 7 2299873 Email: bedie001@yahoo.com

References

1. Prakki A, Cilli R, Costa AU, Goncalues P, Mondelli RL, Pereira CJ. Effect of resin luting film thickness on fracture resistance of a ceramic cemented to dentine. Int J Prosthodont 2007; 16: 172-178.
2. Casson AM, Glyn JC, Youngson CC. The effect of luting media on fracture resistance of the flame sprayed all ceramic crowns. J Dent 2001; 29: 539-544.
3. Bruki CE, Ocampo O. Compressive strength of new foil porcelain-fused-to metal crowns. J Prosthet Dent 1987; 57: 404-410.
4. Christensen GJ. Ceramic vs porcelain-fused-to metal crowns give your patients a choice. J Am Dent Assoc 1994; 125: 311-314.
5. Seghi RR, Denny IL, Rosenstil SF. Relative touhness and hardness of new dental ceramics. J Prosthet Dent 1995; 74: 145-150.
6. Steyerm VP, Ebbesson S, Holmgren J, Haag P, Nilner K. Fracture strength of two oxide ceramic crown systems after cyclic preloading and thermocycling. J Oral Rehabil 2006; 33: 682-689.
7. Steyern V, Jonsson O, Nilner K. Five-year evaluation of posterior all-ceramic three-unite (in-ceram) FPDs. Int J Prosthodont 2001; 14: 379-384.
8. Oden A, Andersson M, Krystek OJ, Magnusson D. Five-year clinical evaluation of all-ceram crowns. J Proth Dent 1998; 80: 450-456.
9. Sundh A, SjÖgren G. A comparison of fracture strength of yttrium-oxide-partially-stabilized zirconia ceramic crowns with varying core thickness, shape and veneer ceramics. J Oral Rehabil 2004; 31: 682-688.
10. Stappert CF, Stathopoulou N, Gerds T, Strub JR. Survival rate and fracture strength of maxillary incisors, restored with different kinds of full veneers. J Oral Rehabil 2005; 32: 266-72
11. Van Dijken J. All ceramic restorations: classification and clinical evaluations. Compend Contin Edu Dent 1999; 20: 1115-1124.
12. Dong JK, Luthy H, Wohlwend A, Schared P. Heat-pressed ceramics: technology and strength. Int J Prosthodont 1992; 5: 9-16.
13. Rosenblum MA, Schuman A. A review of all-ceramic restorations. JADA 1997; 128: 297-307.
14. HÖland W, Schweiger M, Frank M, Rheniberg V. A comparison of the microstructure and properties of the IPS Empress 2 and the IPS Empress glass-ceramic. J Biomed Mater Res 2000; 53: 297-303.
15. Albakry M, Guazzato M, Swain MV. Biaxial flexural strength, elastic moduli, and x-ray diffraction characterization of three pressable all-ceramic materials. J Prosthet Dent 2003; 89: 374-380.
16. Komine F, Tomic M, Gerds T, Strub RJ. Influence of different adhesive resin cements on the fracture strength of aluminum oxide ceramic posterior crowns. J Prosthet Dent 2004; 92: 359-364.
17. Edelhoff D, Sorensen J (2002). Light transmission through all-ceramic framework and cement combinations. Journal of Dental Research (Spec Iss A) 81.)
18. Abdalla AI, Davidson CL. Marginal integrity after fatigue of ceramic inlay restorations luted with three different cements. Am J Dent 2000; 13: 77-80.
19. Burke FJT. The effect of variations in bonding procedure on fracture resistance of dentin-bonded all-ceramic crowns. Quintessence Int 1995; 26: 293-300.
20. Dietschi D, Maeder M, Meyer JM. In vitro resistance to fracture of porcelain bonded to tooth. Quintessence Int 1990; 21: 823-831.
21. Scherrer SS, Rijk WG. The effect of crown length on the fracture of posterior porcelain and glass-ceramic crowns. Int J Prosthodont 1992; 5: 550-557.
22. Thompson JY, Anusavice KJ, Naman A. Fracture surface characterization of clinically failed all-ceramic crowns. J Dent Res 1994; 73: 1824-1832.
23. Gray NJA, Piddock V, Wilson MA. In vitro comparison of conventional crowns and a new all-ceramic system. J Dent 1993; 21: 47-51.
24. Probster L. Compressive strength of two modern all-ceramic crowns. Int J Prosthodont 1992; 5: 409-419.
25. Shor A, Nicholls JI, Philips KM, Libman WJ. Fatigue load of teeth restored with bonded direct composite and indirect ceramic inlays in MOD class II cavity preparations. Int J Prosthodont 2003; 16: 64-69.
26. Strub JR, Beschnidt SM. Fracture strength of 5 different all ceramic crown system. Int J Prosthodont 1998; 11: 602-609.
27. Blatz MB, Sadan A, Martin J, Lang B. In vitro evaluation of shear bond strength of resin to densly sintered high- purity zirconium oxide ceramic after long term storage and thermacycling. J Prosthet Dent 2004; 41: 356-362.
28. Kramer N, Frankenberger R, Pelka M, Petschlt A. IPS Empress inlays and onlays after 4 years a clinical study. J Dent 1999; 27: 325-331.
29. Shortall AC, Fayyad MA, Williams JD. Marginal seal of injection moulded ceramic crowns cemented with three adhesive systems. J Prosthodont Dent 1989; 61: 24-27.
30. Dwan A, Yaman P, Razzoog ME. Effect of cement on fracture resistance of all-ceramic crowns. J Dent Res 1996; 75: 2136-2140.
31. Pameijer CH, Nilner K. Long term clinical evaluation of three luting materials. Swedish Dent J 1994; 18: 59-67.
32. Delong R, Pintado MR, Douglas WH. The wear of enamel opposing shaded ceramic restorative materials. An in vitro study. J Prosthet Dent 1992; 68: 42-48.
33. Sakaguchi RL, Douglas WH, Delong R, Pintodo MR. The wear of posterior composite in an artificial mouth: a

clinical correlation. Dent Mater 1989; 2: 235-240.
34. Rosenstil SF, Land MF, Crispm BJ. Dental luting agents a review of the current literature. J Prosthet Dent 1998; 80: 280-301.
35. Mormann W, Bindl A, Luthyke A. Effect of preparation and luting system on all-ceramic computer-generated crowns. Int J Comput Dent 1993; 11: 333-339.
36. Burke FJT. The effect of variations in bonding procedures on fracture resistance of dentine-bonded all ceramic crowns. Quintessence Int 1995; 26: 293-300.
37. Burke FJT, Watts DC. Effect of differing resin luting systems on fracture resistance of teeth restored with dentin-bonded crowns. Quintessence Int 1998; 29: 21-27.
38. Kern M, Wenger SM. Bonding to zirconia ceramic: adhesion methods and their durability. Dent Mater 1998; 14: 64-71.
39. Waltimo A, Kononen MA. A novel bite force recorder and maximal isometric bite force values for healthy young adults. Scand J Dent Res 1993; 101: 171-175.

Author Information

Manal M. Abou-Madina, BDS, PhD
Asst. Prof., Department of Conservative Dentistry, Faculty of Dentistry, Mansoura University

Khalid M. Abdelaziz, BDS, MS, PhD
Asst. Prof. in Dental Biomaterials, College of Dentistry, Department of Restorative Dentistry, King Khalid University