ORIGINAL ARTICLE

Comparison of Shear Bond Strength of Three Commercially Available Esthetic Restorative Composite Materials: An *In Vitro* Study

Neethu A Preethy[1], Ganesh Jeevanandan[2], Lavanya Govindaraju[3], EMG Subramanian[4]

Abstract

Introduction: Dental caries remains to be one of the most prevalent diseases encountered in the field of dentistry. Several restorative materials have been introduced with variable properties and among them, composite restorative materials are most widely used nowadays because of their superior esthetic property as well as minimal hard tissue removal. Shear bond strength of a restorative material plays a key role in deciding the restoration's longevity. Hence, for a better selection of the composite material, shear bond strength needs to be evaluated.

Aim: The study aim was to analyze the shear bond strength of three commercially available esthetic restorative composite materials—Dentsply Ceram X, 3M ESPE™ Filtek™ Z350 XT, and GC Solare Sculpt to the tooth surface.

Materials and methods: Thirty extracted human mandibular permanent molars that were caries-free were selected and erected in acrylic blocks. The uniform dentinal surface was exposed by cutting with a diamond disk. These were then randomly divided into three groups—groups I, II, and III based on the restorative material which was used, i.e., Ceram X, 3M ESPE™ Filtek™ Z350 XT, and Solare Sculpt, respectively. The restorative materials were applied on the dentinal surface of the prepared tooth specimens with the help of plastic molds, followed up by storing them in distilled water until they were subjected to shear bond strength testing. The collected data were examined by applying a one-way analysis of variance (ANOVA) and Turkey's *post hoc* test.

Results: The Ceram X (21.6155 ± 2.20717) and Solare Sculpt (19.8747 ± 3.99732) were comparable in terms of shear bond strength values; however, they depicted significantly higher bond strength compared to 3M ESPE™ Filtek™ Z350 XT (12.8068 ± 3.99732).

Conclusion: Among the three materials compared in this study, Ceram X produced higher shear bond strength to tooth surface when compared to Solare Sculpt and 3M ESPE™ Filtek™ Z350 XT.

Clinical significance: Restoration failure continues to be a major problem taking a toll on the dentists' time and patient satisfaction. Thus, the demand for restorative materials with better shear bond strength as well as excellent esthetics is on the rise. Thus, this particular study compares the shear bond strength of three commercial esthetic nanocomposites.

Keywords: 3M ESPE™ Filtek™ Z350 XT, Ceram X, Composite, Esthetic, Restoration, Shear strength, Solare Sculpt.

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Introduction

Dental caries continues to be a ubiquitous disease prevailing among the global population and thereby, a continuous demand for better restorative materials and techniques is still underway.[1] Placement and replacement of restorations are the most frequent dental procedure amounting to a major part of the dentists' working time.[2] The pioneering of composite restorative materials has gained popularity mainly because of their superior esthetic properties and minimalistic removal of sound tissue.[3] Continuous technological development of composite materials has taken place in the past few decades. At present, composite resin has made its benchmark in the field of dentistry and is considered to be indispensable and the material of choice for the restoration of anterior and posterior teeth.[4–7]

A normal tooth when subjected to masticatory forces transfers the occlusal biting load through the enamel and into dentin which gets distributed over a large internal volume of tooth structure as compression. This in turn lowers the effect of local stresses. On the contrary, a restored tooth when exposed to such forces tends to transfer the forces along with the tooth–restoration interface, thus leading to complex stress distribution in the form of compression, tension, or shear stress.[8]

The long-term clinical success of any tooth-colored restoration is dependent on the stability of the bond between that of the restoration and tooth substrate.[9–11] The composite resin material was found to exhibit deeper strength and micromechanical interlocking where the dentin was treated with phosphoric acid when compared to treating with polyacrylic acid.[12]

Since the masticatory process is more of a shearing phenomenon, shear bond strength depicts the restorative material's adhesive strength at the tooth-restoration interface.[13] Hence, the bond strength has to be tested in shear mode to yield

[1,2]Department of Pediatric and Preventive Dentistry, Saveetha Dental College, Chennai, Tamil Nadu, India

[3,4]Department of Pedodontics, Saveetha Dental College, Chennai, Tamil Nadu, India

Corresponding Author: Ganesh Jeevanandan, Department of Pediatric and Preventive Dentistry, Saveetha Dental College, Chennai, Tamil Nadu, India, Phone: +91 9884293869, e-mail: helloganz@gmail.com

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a clinically relevant and acceptable test result. With the advent of newer composite materials into the market, the need for selecting an appropriate restorative material for clinical use becomes a critical issue. A survey was conducted among the dental practitioners regarding the choice of composite materials used for esthetic restorations in molars. The results showed that Ceram X, 3M ESPE™ Filtek™ Z350 XT, and GC Solare Sculpt were the most commonly used composite restorative materials. Hence, the present study was conducted to comparatively analyze the shear bond strength of three commercially available esthetic restorative composite materials—Ceram X SphereTEC one (Dentsply Inc.), 3M ESPE Composite (Filtek Z350 XT), and Solare Sculpt (GC Inc.) to the tooth surface as these materials are now gaining popularity as the esthetic restorative material of choice for restoration of permanent molars.

Materials and Methods

The current *in vitro* study was conducted in the Department of Pedodontics and Preventive Dentistry in Saveetha Institute of Medical and Technical Sciences from October to November 2018. The study design was approved by the Institutional Review Board of Saveetha Dental College.

A total of 30 permanent mandibular molar teeth were selected based on the results of the pilot study conducted and the sample size was calculated with 90% power. They were randomly assigned to 3 groups of 10 teeth each. The materials used in this study were group I: Ceram X SphereTEC one (Dentsply Inc.), group II: 3M ESPE Composite (Filtek Z350 XT), and group III: Solare Sculpt (GC Inc.). In all the three study materials, an A1 shade was chosen for the study to ensure uniformity in the study.

Permanent mandibular molars, which were caries-free and extracted due to periodontal reasons, were included in the study. Teeth with occlusal or proximal caries, attrition, any restoration, and root canal treated teeth were excluded from the study. Ultrasonic scaler was used to remove debris adherent to the teeth and they were then stored in distilled water at room temperature till further use as it has the least interference with the bond strength.[14]

The selected teeth were mounted in an auto-polymerizing orthodontic resin using custom-made wax molds of 3 × 1.5 × 1.5 cm for standardization. The teeth were placed in such a way that their occlusal surface was parallel to the resin block surface. The teeth were then sectioned horizontally between the middle and occlusal third of the tooth with a double-faced diamond disk beneath the dentinoenamel junction, so that the corono-dentinal surface is exposed. Wet silicon carbide paper of 180, 320, and 600 grit was used to polish the dentinal surface making it uniformly flat. Thermocycling was not done to simulate oral conditions in the present study as variations in the temperature do not have a significant effect on the restorative materials, rather it may lead to spontaneous debonding of the specimens.[15] The specimens were transferred for storage in distilled water at 37°C for 24 hours after which they were randomly divided into 3 groups of 10 teeth under each group. The materials to be tested under each group were as follows (Fig. 1):

Group I: Ceram X SphereTEC one (Dentsply Inc.).

Group II: 3M ESPE Composite (Filtek Z350 XT).

Group III: Solare Sculpt (GC Inc.).

The teeth were etched with 37% ortho-phosphoric acid (DenOR-DenEtch) for about 15 seconds and rinsed with water for 10 seconds. They were then blotted dry using cotton pellets. A bonding agent (3M ESPE ADPER Single bond Universal Adhesive) was then applied in two coats using a fully saturated disposable tip. Light curing was done for 10 seconds. Readymade plastic molds of 5 mm internal diameter and 5 mm height were taken and the inner surface of the molds was coated with petroleum jelly. These molds were used to bond the restorative material to the tooth surface. The molds were placed on the tooth surface and were then subsequently filled and condensed with the respective restorative composite materials in 2 mm increments at room temperature and were light-cured (Woodpecker LED curing light) for 20 seconds each. This cured restorative material was then pushed out of the plastic mold with a ball burnisher (Fig. 2) as done in a similar study by Nujella et al.[13]

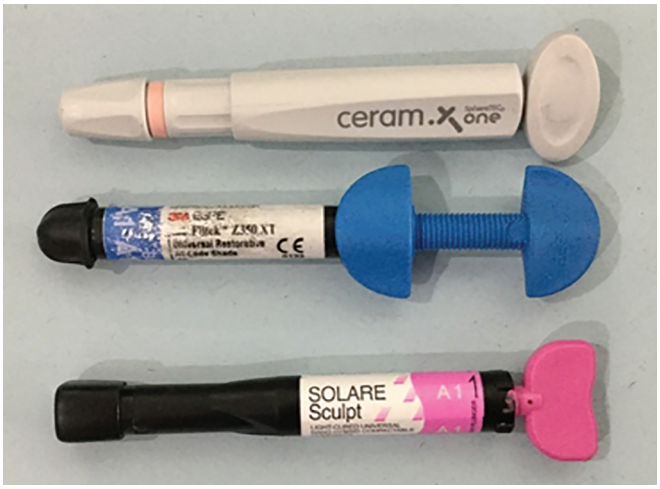

Fig. 1: The three material groups used for the study for which shear bond strength is to be compared

All the 30 specimens were then placed in distilled water for 24 hours at 37°C after which they were subjected to shear bond strength testing using Hounsfield Universal Testing Machine (Instron, USA) at a crosshead speed of 0.5 mm/minute following the 2003 ISO technical specification #11405[16] (Fig. 3).

Statistical Analysis

The data obtained were tabulated and analyzed using one-way analysis of variance (ANOVA) and Turkey's *post hoc* tests utilizing SPSS software version 23.0. A probability value of <0.05 was considered significant.

Results

The mean values of the shear bond strength of the three restorative materials are depicted in Table 1. The shear bond strength was found to be highest with Ceram X SphereTEC One (Dentsply Inc.) followed by Solare Sculpt (GC Inc.) and 3M ESPE Composite (Filtek Z350 XT). *Post hoc* tests (Table 2) for shear bond strength revealed that there was no significant difference in Ceram X SphereTEC one and Solare Sculpt composite restorative materials, while the strength was statistically lower in 3M ESPE composite material.

Discussion

The bond between materials used in dentistry to the tooth should be strong and durable, not only from a mechanical point of view but also from biological and esthetic perspectives.[17] Bond strength value acts as a gross assessing tool to evaluate the bonding efficacy of any

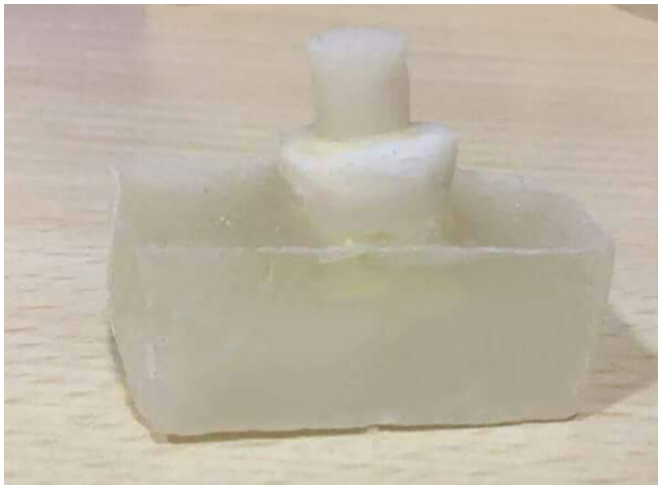

Fig. 2: Preparation of the specimen and bonding with the respective material according to the group

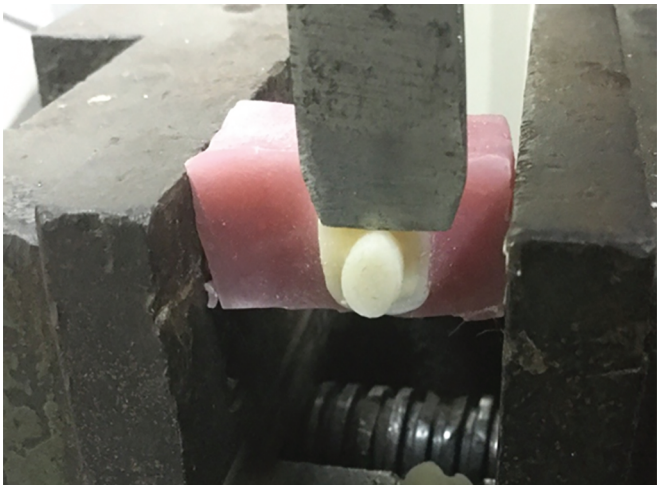

Fig. 3: Instron UTM machine used to measure the shear bond strength of the material

Table 1: Comparison of shear bond strength of the three material groups

Groups	*N*	*Mean*	*Std. deviation*	*p value*
Group I	10	21.6155	2.20717	0.002**
Group II	10	12.8068	3.99732	
Group III	10	19.8747	7.66814	

One-way ANOVA ($p \leq 0.01$)
**Highly significant

Table 2: *Post hoc* tests comparing the three groups (mean difference and significance of difference)

Groups				
A	*B*	*Mean difference (A–B)*	*Std. error*	*Significance of difference*
Group I	Group II	8.80873*	2.30435	0.002
	Group III	1.74084	2.30435	0.733
Group II	Group I	−8.80873*	2.30435	0.002
	Group III	−7.06789*	2.30435	0.013
Group III	Group I	−1.74084	2.30435	0.733
	Group II	7.06789*	2.30435	0.013

*The mean difference is significant at the 0.05 level

restorative material to the tooth.[8] The advent of nanotechnology has led to the production of nanocomposites with a particle size ranging from 0.1 to 100 nm. Due to the reduced particle size and wider distribution, filler loading can be increased, thereby reducing the amount of polymerization shrinkage.[18] The present study compared the shear bond strength of commercially available three different esthetic composite restorative nanocomposite materials of A1 shade—group I: Ceram X SphereTEC one (Dentsply Inc.), group II: 3M ESPE Composite (Filtek Z350 XT), and group III: Solare Sculpt (GC Inc.) as these materials are currently gaining popularity for the esthetic restoration of posterior teeth.

The present study was conducted as an *in vitro* study, as assessing the clinical functions and mechanical characteristics of restorative material is difficult *in vivo*.[19,20] Thus, *in vitro* testing to assess shear bond strength proves to be the least technique sensitive to perform and predicts the possible clinical performance of the material by emphasizing the strength at the bonded interface.[8,19]

The shear bond strength of Ceram X was found to be the highest with a mean of 21.6 MPa in the current study. Ceram X contains SphereTEC fillers (≈15 µm) which are combined with non-agglomerated barium glass fillers (≈0.6 µm) and ytterbium fluoride (≈0.6 µm). The composite also comprises highly dispersed, methacrylic polysiloxane nanoparticles that are chemically similar to glass or ceramics. Thus, it can be referred to as a nanohybrid composite with prepolymerized fillers.

The mean shear bond strength of Solare sculpt GC is 19.87 MPa. Solare sculpt has unique, hemogeneous, pre-polymerized nanofillers with high density and uniform dispersion silane treatment technology and contains 300-nm strontium hemogeneously dispersed glass fillers with a filler weight of 79%.

The mean shear bond strength of 3M ESPE™ Filtek™ Z350 XT composite was 12.80 MPa. 3M ESPE™ Filtek™ Z350 XT Universal Restorative Resin System consists of three major components. The majority of TEGDMA (triethylene glycol-dimethacrylate) was replaced with a blend of UDMA (urethane-dimethacrylate) and bis-EMA (ethoxylated bisphenol A glycol dimethacrylate). Triethylene glycol-dimethacrylate and poly-ethylene glycol dimethacrylate (PEGDMA) are used in minor amounts to adjust the viscosity. Poly-ethylene glycol dimethacrylate was used to replace part of the TEGDMA to moderate shrinkage. It contains nanoclusters in a wide range of sizes to enable high filler loading. It contains zirconia/silica clusters, silica nanoparticles, and zirconia nanoparticles. In a study comparing the microleakage of three different direct composite resins using self-etching primer, it was found that 3M ESPE™ Filtek™ Z350 showed the least amount of microleakage.[21] However, despite the lower microleakage, in the present study, the material has shown to have the least shear bond strength and it is statistically significant when compared with the other two materials used.

The coronal dentin surface of the tooth was used to analyze the shear bond strength in the present study as the previous studies have shown a reduction in the bond strength when resin composite is bonded to deep dentin[22,23] and this can be attributed to the complexities in the structure of deep dentin, such as an increase in the number of tubules and their diameters with much less intertubular dentin matrix when compared to superficial dentin.[24]

LED curing light was used for curing in the present study, as a review on the effects of LED and QTH light-curing lights revealed that LED light-curing units offer equal or better performance in the curing of nanocomposite materials when compared to QTH light-curing units.[25]

Despite the esthetic advantages of composite resins, restoration failure continues to be a problem.[26] Restorative materials should have a high shear bond strength to withstand the masticatory forces. The filler volume and filler weight level of the composites have been found to correlate with the material strength and elastic modulus.[27] According to a study by Watts et al.,[28] the composites with relatively high filler content exhibited a significant reduction in volumetric shrinkage, accompanied by lower contraction stress value. Thus, it has been found that a combination of lower shrinkage and decreased stress produces high bond strength.[29]

In a study by Boyer et al., high fillers were found to be associated with increased bond strength with no effect on elasticity and a reduction in polymerization shrinkage.[30] In the present study, the mean shear bond strength was the highest in group I (Ceram-X). However, the *post hoc* tests have shown that the shear bond strength of Ceram-X and Solare Sculpt restorative materials are comparable. The higher shear bond strength of these materials may be due to the advanced granulated filler technology which in turn leads to increased bond strength at the restoration–tooth interface. This fact is supported by a study conducted by Rathore et al., which have shown that the nanofilled composites have higher shear bond strength compared to the microfilled composite as the former had comparatively higher filler loading and were silane treated.[31] Also, it was advocated that the shear bond strength of a restorative material can be increased by the use of sandblasting, bur, and hydrofluoric acid at the composite interface.[32]

The composite materials used in the present study being the most commonly used, the practitioners should also be aware of the other recently introduced advanced composite materials like the self-etched composites, nano-carbon composites, and evaluating their shear bond strength can give a better scope for composite restorations in the dental practice. Also, the *in vitro* results cannot be directly applied to the clinical situations and hence, a comprehensive evaluation of the restorations should be conducted to conclude on their performance.

Conclusion

Ceram X Dentsply and Solare Sculpt restorative materials have higher shear bond strength and can be beneficial when used for esthetic restorations leading to the long-term clinical success of the restoration.

Clinical Significance

Nanocomposite materials have revolutionized the field of restorative dentistry with its several meritorious properties. Since posterior teeth are mostly subjected to a shearing phenomenon during mastication, placement of the restorative material with better shear bond strength is recommended for these teeth to elude restoration failure and increase patient satisfaction.

References

1. Marcenes W, Kassebaum NJ, Bernabé E, et al. Global burden of oral conditions in1990–2010: a systematic analysis. J Dent Res 2013;92(7):592–597. DOI: 10.1177/0022034513490168.
2. Mjor IA, Shen C, Eliasson ST, et al. Placement and replacement of restorations in general dental practice in Iceland. Oper Dent 2002;27:117–123.
3. Ferracane JL. Resin composite—state of the art. Dent Mater 2011;27(1):29–38. DOI: 10.1016/j.dental.2010.10.020.
4. de Moura FRR, Romano AR, Lund RG, et al. Three-year clinical performance of composite restorations placed by undergraduate dental students. Braz Dent J 2011;22(2):111–116. DOI: 10.1590/S0103-64402011000200004.
5. Correa MB, Peres MA, Peres KG, et al. Amalgam or composite resin? Factors influencing the choice of restorative material. J Dent 2012;40(9):703–710. DOI: 10.1016/j.jdent.2012.04.020.
6. Baldissera RA, Corrêa MB, Schuch HS, et al. Are there universal restorative composites for anterior and posterior teeth. JDent 2013;41(11):1027–1035. DOI: 10.1016/j.jdent.2013.08.016.
7. Demarco FF, Baldissera RA, Madruga FC, et al. Anterior composite restorations inclinical practice: findings from a survey with general dentalpractitioners. J Appl Oral Sci 2013;21(6):497–504. DOI: 10.1590/1679-775720130013.
8. Jain G, Narad A, Boruah LC, et al. Comparative evaluation of shear bond strength of three resin based dual-cure core build-up materials: an in-vitro study. J Conserv Dent JCD 2015;18(4):337–341. DOI: 10.4103/0972-0707.159754.
9. Ikeda M, Tsubota K, Takamizawa T, et al. Bonding durability of single-step adhesives to previously acid-etched dentin. Oper Dent 2008;33(6):702–709. DOI: 10.2341/08-26.
10. Meerbeek BV, Landuyt KV, Munck JD, et al. Technique-sensitivity of contemporary adhesives. Dent Mater J 2005;24(1):1–13. DOI: 10.4012/dmj.24.1.
11. Korkmaz Y, Gurgan S, Firat E, et al. Shear bond strength of three different nano-restorative materials to dentin. Oper Dent 2010;35(1):50–57. DOI: 10.2341/09-051-L.
12. Almuammar MF, Schulman A, Salama FS. Shear bond strength of six restorative materials. J ClinPediatr Dent 2001;25(3):221–225. DOI: 10.17796/jcpd.25.3.r8g48vn51l46421m.
13. Nujella BPS, Choudary MT, Reddy SP, et al. Comparison of shear bond strength of aesthetic restorative materials. Contemp Clin Dent 2012;3(1):22–26. DOI: 10.4103/0976-237X.94541.
14. Titley KC, Chernecky R, Rossouw PE, et al. The effect of various storage methods and media on shear- bond strengths of dental composite resin to bovine dentine. Arch Oral Biol 1998;43(4):305–311. DOI: 10.1016/S0003-9969(97)00112-X.
15. Tezvergil A, Lassila LVJ, Vallittu PK. Composite-composite repair bond strength: Effect of different adhesion primers. J Dent 2003;31(8):521–525. DOI: 10.1016/S0300-5712(03)00093-9.
16. International Organization for Standardization. ISO/TR 11405 Dental Materials-guidance on Testing of Adhesion to Tooth Structure. Geneva, Switzerland: WHO; 1994. pp. 1–13.
17. Manuja N, Pandit IK, Srivastava N, et al. Comparative evaluation of shear bond strength of various esthetic restorative materials to dentin: an in vitro study. J Indian SocPedod Prev Dent 2011;29(1):7–13. DOI: 10.4103/0970-4388.79913.
18. Beun S, Glorieux T, Devaux J, et al. Characterization of nanofilled compared to universal and microfilled composites. Dent Mater 2007;23(1):51–59. DOI: 10.1016/j.dental.2005.12.003.
19. Petronijević B, Marković D, Šarčev I, et al. Fracture resistance of restored maxillary premolars. Contemp Mater 2012;3:219–225.
20. Hegde MN, Vyapaka P, Shetty S. A comparative evaluation of microleakage of three different newer direct composite resins using a self etching primer in class V cavities: an in vitro study. J Conserv Dent JCD 2009;12(4):160–163. DOI: 10.4103/0972-0707.58340.
21. Cohen BI, Pagnillo MK, Deutsch AS, et al. Fracture strengths of three core restorative materials supported with or without a prefabricated split-shank post. J Prosthet Dent 1997;78(6):560–565. DOI: 10.1016/S0022-3913(97)70006-4.
22. Srinivasulu S, Vidhya S, Sujatha M, et al. Shear bond strength of composite to deep dentin after treatment with two different

collagen cross-linking agents at varying time intervals. Oper Dent 2012;37(5):485–491. DOI: 10.2341/11-232-L.
23. Dhanyakumar S. Comparative evaluation of micro-shear bond strength of adhesive resins to coronal dentin versus dentin at floor of pulp chamber - an in vitro study. J Conserv Dent 2006;9(4):123–130. DOI: 10.4103/0972-0707.42313.
24. Tagami J, Tao L, Pashley DH. Correlation among dentin depth, permeability, and bond strength of adhesive resins. Dent Mater 1990;6(1):45–50. DOI: 10.1016/0109-5641(90)90044-F.
25. Nishad NT, Sujeer R, Toby TH, et al. Curing efficacy of LED and QTH light curing units for curing nanocomposite resins – a systematic review. IOSR J Dent Med Sci 2013;11(2):36–44. DOI: 10.9790/0853-1123644.
26. Imbery TA, Gray T, DeLatour F, et al. Evaluation of flexural, diametral tensile, and shear bond strength of composite repairs. Oper Dent 2014;39(6):E250–E260. DOI: 10.2341/13-299-L.
27. Siso SH, Hurmuzlu F. Physical properties of three different types of LC composite resins. Acta Stomatol Croat 2008;42:147–154.
28. Watts DC, Vogel LK, Maroufi AS. Shrinkage stress reduction in resin-composites of increasing particle concentration [abstract 2444]. J Dent Res 2002;81(2):114–118. DOI: 10.1177/0810114.
29. El-Sahn NA, El-Kassas DW, El-Damanhoury HM, et al. Effect of C-factor on microtensile bond strengths of low-shrinkage composites. Oper Dent 2011;36(3):281–292. DOI: 10.2341/10-105-L.
30. Boyer DB, Chalkley Y, Chan KC. Correlation between strength of bonding to enamel and mechanical properties of dental composites. J Biomed Mater Res 1982;16(6):775–783. DOI: 10.1002/jbm.820160604.
31. Rathore VPSS, Hotkar CG, Patel P, et al. Comparative evaluation of shear bond strength of microfilled & nanofilled composite resin cured under LED: an in-vitro study. IJOCR 2015;3(9):4–7.
32. Alexander AK, Priya RM, Sarthaj S, et al. Comparitive evaluation of different surface treatments on the repair shear bond strength of three nanohybrid composites: an *in-vitro* study. Cons Dent Endod J 2018;3(1):22–26.