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Original Article

Marginal Adaptation of One Bioactive Bulk Fill Material And Three Bulk Fill Resin Based Composites in MOD Cavities

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Abstract

Objectives: The objective of the present study is to evaluate and compare the marginal adaptation of one bioactive bulk fill material and three different bulk-fill resin based composites.
Materials and methods: Class II slot cavities were prepared in eighty sound human molar teeth. The teeth were divided into four equal groups (n=20). Group I: cavities were restored with Activa bioactive restorative, Group II: cavities were restored with Sonic-fill bulk fill, Group III: cavities were restored with Tetric EvoCeram Bulk Fill and Group VI: cavities were restored with Filtek Posterior bulk fill respectively. All teeth were subjected to thermocycling, gold sputtering and marginal adaptation was evaluated using scanning electron microscope. Collected data were analyzed by kurskal Wallis test.
Results: No significant differences in marginal adaptation were found between the four tested groups (P< 0.05).
Conclusions: Under the limitations of this in vitro study, it was concluded that all the tested bulk fill materials showed acceptable marginal adaptation after thermocycling with no significant differences between them.
Keywords: Activa Bioactive; Sonic-fill; Bulk-fill; Marginal adaptation; SEM.

Introduction:
Recently, demand for aesthetic and fear of mercury hazards have been increased obviously. Dentists became more knowledgeable and interested in conservatism and minimally invasive procedures. This was in line with the innovations, simplifications of adhesive systems and composites. All these factors in addition to good mechanical properties and durability of resin based composites contributed to the consideration of resin based composite as the material of choice for most patients and dentists for restoration of anterior and posterior teeth.[1]

Resin based composite have many limitations, but the most challenging of them are polymerization shrinkage stresses and limited depth of cure.[2,3,4] Many trials have been proposed in literature to reduce polymerization shrinkage stresses, such as using low modulus liner, soft start photo-activation methods,[5] and using layering technique by applying and curing composite in layers not exceed 2mm in depth.[6]This challenge does not end there, as layering protocol has also some limitations such as, inclusion of bubbles and contaminant between layers, technique sensitivity and long time needed to restore posterior teeth.[7]

The most recent attempt to simplify restoration procedure, debate the limitation of layering protocol and compensate polymerization shrinkage stresses is to use Bulk fill composites containing new resin monomers with novel chemistries (low polymerization shrinkage).[8,9]

Tetric Evoceram Bulk Fill incorporates one of these novel chemistries. It contains an extra light initiator system named Ivocerin which is highly sensitive, has an absorption spectrum similar to camphorquinone and based on di-benzoyl germanium derivatives. This highly reactive polymerization booster has higher light absorption rate in the visible wave length range. Another novel ingredient is stress reliever which is added to the filler composition. It acts as microscopic spring during polymerization as it has low modulus of elasticity. So relief of shrinkage stresses is claimed.[10]

Another innovation was the unique addition fragmentation monomer incorporated in Filtek bulk fill posterior restorative. As polymerization takes place, this monomer may undergo fragmentation process and cleave. This cleavage provides a relaxation of the polymeric network while development with subsequent relief of stresses that allows the restoration to be placed as a bulk.[11]

Subsequently, Sonic Fill system was introduced into the market in the form of three successive generations 1, 2 and 3. It is indicated for use as a bulk fill posterior composite restorations and can be applied in as one layer of 5 mm depth because of its claimed reduced polymerization shrinkage. It contains a filler loaded resin and special modifiers which react to sonic energy applied through the hand piece. This leads to dropping the viscosity (up to 87 %), implementing easy application and good sealing to the cavity. After stopping the sonic activation, it regains its viscosity and becomes easy to carve and contour.[12] While Sonic activation objectives are to improve the adaptation of the composite to the cavity, this improvement in marginal adaptation over the other bulk fill resin based composites is still unproven.[13]

Marginal adaptation is the sealing of the restorative material to the cavity margins. Poor sealed margins, causes microleakage, subsequent secondary caries and postoperative sensitivity. The use of good bonding agent and fluoride-releasing materials increases the marginal adaptation.[14]

Recently an innovative bulk fill restorative material was launched in the market, but with additional bioactive properties, namely Activa Bioactive Restorative. It is a bioactive composite possesses Glass ionomer advantages. It is composed of a resin component with shock-absorbing property and ionic resinous matrix loaded with bioactive fillers. As a result of these bioactive properties, it is claimed to enhance marginal adaptation at the tooth–restoration interface.[15]

Therefore the aim of the present *invitro* study is to evaluate and compare the marginal adaptation of a one new bioactive restorative material (Activa Bioactive) and three resin based bulk fill composites (SonicFill, Tetric Evoceram & Filtek Bulk Fill) in MOD cavities.

Materials and Methods:

Eighty freshly extracted human lower molar teeth of comparable size, extracted for periodontal reasons from volunteers (age 30-45) were selected for this study (Oral Surgery Department, Faculty of Dentistry, Kafr Elsheikh University). The teeth were free-from caries, restorations, cracks or other defects. All selected teeth were cleaned with a hand (Optilux, Kerr Deteron Orange, USA) and ultrasonic scaler (Meta Dental Com, Korea) from any soft tissues or calculus. The selected teeth were stored in 0.05% sodium azide solution (Al_Nile Chemical Comp. Egypt), for 24 hours to prevent bacteria or fungus growth in the storage medium, then stored in distilled water until the experiment time.[16]

Faciolingual and mesiodistal dimensions of the teeth were measured at the cemento-enamel junction using a metal gauge (Hu-Fricdy, Chicago, IL). The maximum differences among selected teeth in faciolingual dimension were 0.7 mm and in mesiodestal dimentions were 0.4 mm.

Sample grouping:

The selected teeth were randomly assigned into four equal groups (n = 20) according to the used restorative materials. The restorative materials used in this study are listed in Table (1).

The prepared cavities were restored with:

Group I: Activa bioactive bulk fill material.

GroupII: Sonic Fill bulk fill resin based composite.

GroupIII: Tetric EvoCeram bulk fill resin based composite.

Group VI: Filtek posterior restorative bulk fill resin based composite.

Specimens Preparation

Teeth were demarcated 2mm below cement-enamel junction. A 3-cm polyvinyl chloride tube (1.27cm width) was filled with acrylic resin material in the dough stage, then the teeth were embedded in acrylic resin cylinder center, parallel to its long axis, to a level of 2 mm below the cement-enamel junction as this position is the average position of the tooth in the alveolar bone. Specially designed Jig was used to standardize the correct position and angulation of each tooth inside PVC tube.

Standardized teeth preparation:

Standardized large MOD cavity preparation was prepared using a No.245 carbide bur (Meta Dental, Korea) connected to high speed hand piece (NSK PanaAir FX, Japan) ,with water coolant, and the cavities were finished with finishing diamond points. The cavity width was (3 ± 0.3 mm) and depth (4 ± 0.3mm) from the cavity occlusal cavosurface margin to the pulpal floor. The buccal and lingual walls were prepared parallel without occlusal convergence. The slot MOD cavities were prepared without proximal boxes in order to reduce the preparation variation. No bevels were applied to cavosurface margins, and all internal line angles were rounded (Fig 1). A Tofflemire matrix band (Shofu Dental, MFG. Co, Ltd) was contoured and placed around the teeth and held firmly at the proximal aspects of the teeth using rubber stoppers fixed to Ivory no.1 holder (Fig.2)

Restorative protocol

Group I: Activa Bioactive Restorative

The teeth in this group were restored with Activa bioactive Restorative/ Single Bond Universal. The enamel was selectively etched for 15 seconds, rinsed and lightly dried with a cotton pellet to remove excess water. A bonding agent was applied. The mix tip was placed at cavity floor and Activa was applied in one increment, keeping mix tip submerged in the material. Dual cure material was allowed to self-cure 20-30 seconds before light curing for 20 seconds. Then the restorations were light-cured from the buccal and lingual aspects for an additional 20 Seconds on each side with a LED light curing unit (Woodpecker® Dental Curing Light LED D) with output irradiance of approximately 850-1000 mW/cm.

Group II: SonicFill

The teeth in this group were restored by SonicFill/OptiBond Universal. After selective etching and bonding the uni-dose tip was attached to the specially designed handpiece. The tip was placed at the floor of the cavity, and activation of sonic energy was started, enabling the flow of composite into the cavity preparation. Then the sonic energy was stopped, and the composite regained its viscosity and its non-slumping state for carving and contouring. And then light curing for 20 seconds was done.

Group III: Tetric EvoCeram

For this group, Tetric EvoCeram/Adhese Universal was used for restoration. The enamel was selectively acid etched for 15 seconds; a single layer of Adhese universal adhesive was applied to the cavity surface and scrubbed for 10 seconds. Then the excess material was removed with a gentle stream of air and light-cure for 10 seconds**.** The entire cavity was filled in single increment, adapted to the cavity with a condenser and then light cured for 20 seconds.

Group IV: Filtek Posterior restorative

The teeth of this group were restored with Filtek Posterior Restorative/Single Bond Universal, after selective acid etching, the adhesive Single Bond Universal was used. The adhesive was applied using micro-brush to the prepared cavity walls and floors and left for 20 seconds, then air-dried for five seconds and then light cured for 10 seconds. Each cavity was restored with single increment, adapted to the cavity with a condenser (DIA Dent Gp, Meta Dental, Korea) and then light cured for 20 seconds.

Thermocycling:

All specimens were subjected to thermocycling between 5Cº to 55Cº in a water bath for a total of 2000 cycle with 10 seconds dwell time at each bath using thermocycling device.

Marginal adaptation test:

The teeth were gold sputtered, quantitative and qualitative marginal analysis were carried out using SEM at 500 X magnification. Marginal micrographs were evaluated for the following: continuous and non-continuous margin along the outer periphery of the restorations.[17] (Fig.3). The overall margins were evaluated for gaps and the maximum gaps width was estimated if found, then each restoration was given scores based the following criteria:

Score 0: No gaps at the margins.

Score 1: Gaps with estimated maximum width <30µm

Score 2: Gaps with estimated maximum width >30 µm

Statistical Analysis:

Collected data from the marginal adaptation test were subjected to statistical analysis using the Statistical Package for Social Science (SPSS Inc, Chicago, IL, US). Kruskal-Wallis Test was conducted to examine the differences in marginal adaptation score according to the restorative material used.

Results:

Table (2) shows the proportioning of samples in the four tested groups according to marginal adaptation scoring. **In group I**, all the tested samples recorded score 0 with continuous margins and no evidence of marginal gap formation. **In group II**, eighteen tested samples exhibited continuous margins with score 0, and only two samples recorded score 1 i.e. showed marginal gaps with mean gap width <30µm**. Group III and VI** showed nearly the same results as sixteen samples in each of them scored 0 with continuous margins, while the remaining four samples recorded score 1. In all the four tested groups, there were no samples scored 2.

Kruscal-Wallis Test was conducted to examine the differences in marginal adaptation scores according to the restorative material used. The results of the test revealed no significant differences (Chi square = 5.029, p = .174, Df = 3) were found among the four groups. **Table (3)**

Discussion:

Marginal adaptation is a very important factor that positively affects durability of any restoration inside the oral cavity. Loss of marginal adaptation, subsequent microleakage and failure of composite restorations is a sequel of increased polymerization shrinkage stresses.[18] reasonably; all clinicians must aim to achieve better marginal seal for their composite restorations.

Table (1): Restorative materials specification and composition

Material	Specification	Composition	Manufacturer
ACTIVA™ BioACTIVE Restorative	bioactive composite	Resin matrix: Blend of diurethane and other methacrylates with modified polyacrylic acid Filler: Silica, amorphous and Sodium fluoride	PulpDent Corp, MA, USA
Tetric EvoCeram	Nanofilled Bulk fill resin	Resin Matrix: UDMA, Bis-GMA Filler: Barium glass, ytterbium trifluoride, mixed oxide and pre polymer	Ivoclar Vivadent, Schaan,Liechtenstein
Filtek™ Posterior Restorative	Nanohybrid bulk fill resin	Resin Matrix: Aromatic UDMA, UDMA, ERGP-DMA, Diurethane-DMA and 1,2- dodecane-DMA Filler: Non-agglomerated/non aggregated 20 nm filler, non agglomerated/non aggregated 4 _ 11 zirconia filler, aggregated zirconia/silica cluster filler and a ytterbium trifloride filler	3M ESPE, St. Paul, MN, USA
SonicFill	Sonic activated bulk fill resin based composite	Bis-GMA; TEGDMA; UDMA; Bis-EMA Filler: silicon, barium, boron, aluminium, glass, and oxides. Organic and inorganic rheology modifiers	Kerr Corporation, Orange, CA, USA)

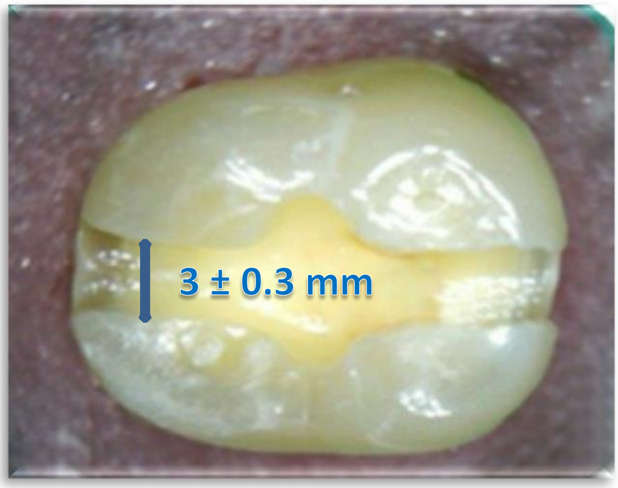

Figure 1: MOD cavity prepared in lower molar. The cavity width is (3 ± 0.3 mm) and depth is (4 ± 0.3mm) without proximal boxes.

Figure 2: Tofflemire matrix band was contoured and placed around the teeth and held firmly by ivory No. 1 holder and rubber stoppers at the proximal aspects of the teeth.

Marginal adaptation of any restorative material to the cavity margins can be measured by either microleakage and dye penetration test or marginal adaptation measurements. Achieving a quantitative analysis of the marginal adaptation in the form of continuity, presence of irregularities and gaps with estimating the width of gaps is chosen for the present study rather than qualitative measuring of microleakage.

The scanning electron microscope was used to differentiate between marginal adaptations of different specimens. Electron microscope scanning in the present study was done directly on the restored teeth because it showed many advantages over indirect epoxy resin replicas scanning. As epoxy resin replica fabrication is a procedure that consumes long time and may express excess resin and voids at the margins.

In the current study, all teeth are of comparable size and the cavities were standard in dimensions and design, providing the same C-factor for all the restoration specimens.[19]

Bulk fill resin based restorative materials recently launched to the market with manufacturers' claims to decrease polymerization shrinkage and its subsequent stresses. Therefore, in the current study, four different bulk fill resin based composite materials were evaluated.

Activa Bioactive is a bioactive restorative material composed of a novel bioactive ionic resin, rubberized resin and bioactive glass ionomer. It possesses esthetic, strength, wear resistance and elasticity of resin composites and bioactive properties and fluoride release of glass ionomers. Also it chemically bonds to the tooth via ionization reaction and forms a strong resin-hydroxyapatite complex thereby sealing the tooth against bacterial microleakage.[15]

Table 2: Proportioning of samples in different groups according marginal adaptation scoring

Marginal adaptation	Group I (Activa)	Group II (Sonic fill)	Group III (Tetric)	Group IV (Filtek)
Score 0	20	18	16	16
Score 1	0	2	4	4
Score 2	0	0	0	0

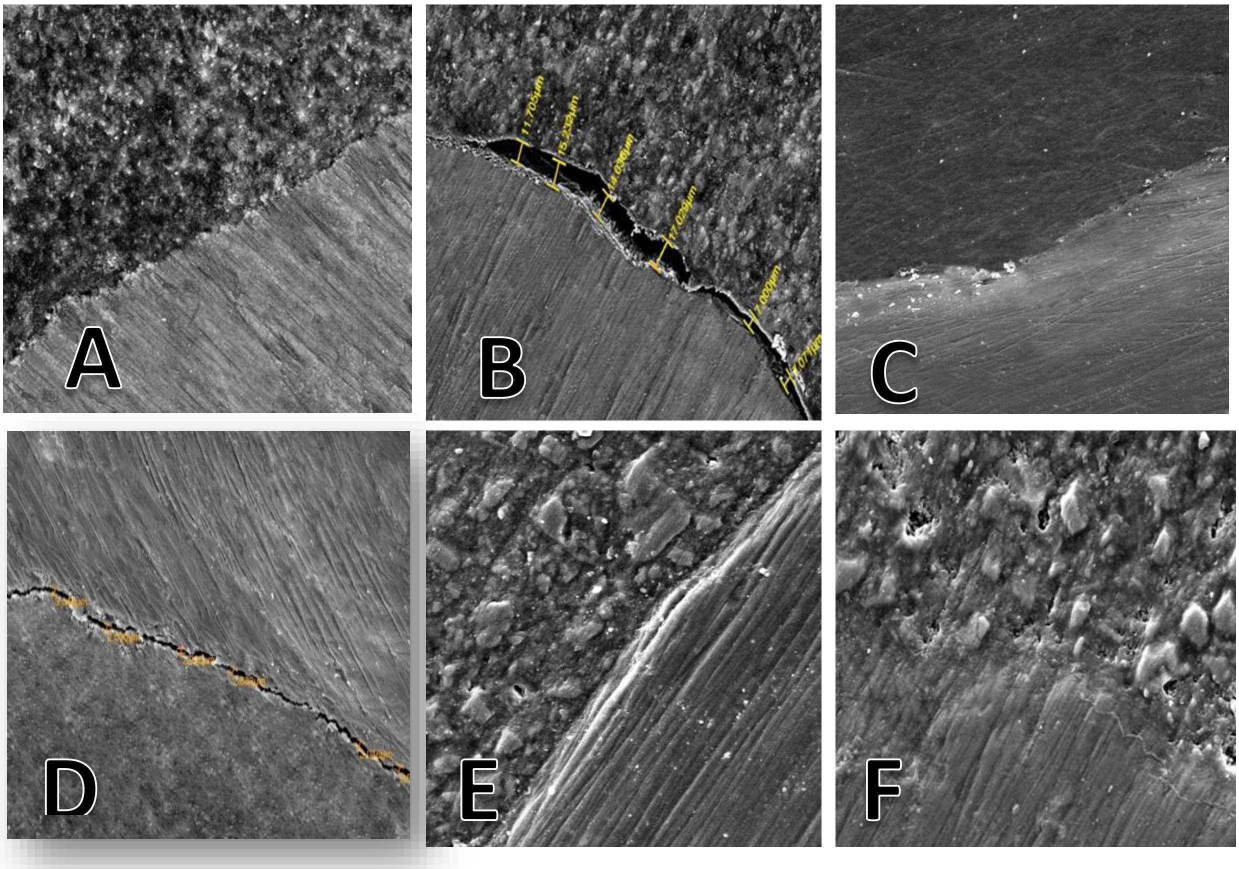

Figure 3: Representative Stereomicroscopic images of: (A) Continuous margin of Tetric Evoceram Bulk fill. (B) Non continuous margin for Tetric EvoCeram. (C) Continuous margin for Filtek posterior (D) Non continuous margin for Filtek posterior. (E) Continuous margin for Activa. (F) Continuous margin for Sonic Fill.

Table (3): Kruscal-Wallis test comparing marginal adaptation of the tested groups

Groups	Mean rank	
Group I	35.5	
Group II	39.5	
Group III	43.5	
Group IV	34.5	
Test Value	Chi square	5.029
	P Value	0.170

In this study, results revealed no significant differences between the four restorations in marginal adaptation. The slight superior sealing of Activa bioactive could be attributed to its patented rubberized resin and the ionization reaction that form hydroxyapatite bond to the tooth. Also, earlier laboratory researches has evaluated flexural strength of activa bioactive bulk fill that was similar to that of other bulk-fill resin composites.[20,21] The low elastic modulus and the greater elastic deformation of the material during stresses were determined in literature.[22] The results of present study are in agreement with Bishnoi, et al. who concluded that Activa bioactive bulk fill composite restorations showed the least microleakage, amongst the tested bulk fill restorations but with no significant difference.[23]

Also, the results of the present study are in agreement with Benetti, et al[24] and Kaushik and Yadav,[25] who concluded that Activa Bioactive Restorative when used after bonding procedure revealed acceptable and comparable marginal sealing to that of other tested composite restorations.

While the present study disagrees with that of Owens, et al. who concluded that using bioactive material in Class V cavities resulted in less marginal adaptation than a hybrid composite resin and resin-modified glass ionomer with significant difference. This may be explained by absence of boding agent application before restorative procedure. [26]

Sonic Fill showed slight better marginal adaptation than other two bulk fill resin based composites with no significant differences; this may be explained by increased fluidity during application. Peutzfeldt and Asmussen concluded that fluidity level in the application of the resin composite increase the marginal adaptation. In addition, Sonic Fill is heavily filled—84% by weight. This high filler loading lead to decreased volumetric shrinkage of sonic fill 1.6% as reported in literature.[27,28] Another study that reported better marginal seal for sonic Fill composite resin in comparison to other restorative bulk fill resin based restorations.[19]

For Tetric EvoCeram, the good results may be associated with higher filler loading, and improved elasticity modulus. This also may be attributed to the presence of hydroxyl free BIS-GAMA and other branched methacrylate groups that enable good adaptation without necessity of incremental placement. Beside the previously mentioned factors, Tetric EvoCeram contains innovative stress reliever fillers that have low modulus of elasticity about 10 MPa. These fillers may work on keeping chemical cushion between the coarse filler particles and improve the elasticity of the restoration.

Also, Tetric EvoCeram contains new highly sensitive and reactive light initiator system (Ivocerin) in the presence of the conventional (Camphorquinone) initiator. This combination was applicable because they have the same absorption spectrum. Higher light absorption rate of Ivocerin enables higher reactivity to light. So, polymerization can be triggered with very little photons and thus the depth of cure is increased.[10]

Regarding the good results for Filtek posterior restorative, this may be due to incorporation of novel addition fragmentation monomer in it that, work to lower the polymerization stress. On the other hand, Filtek posterior restorative based on monomers with higher molecular weight (AUDMA, UDMA and 1, 12-dodecane-DMA), and highly loaded filler (76.5%), which are acting together to reduce polymerization shrinkage. Also decreased viscosity of this material by modifying the monomers and adding hydroxyl free BIS-GMA methacrylate may contribute to increase adaptability.[11] One study evaluated the physio-mechanical properties of bulk fill materials and elastic modulus results indicated that Filtek posterior restorative had elastic modulus values similar to dentine of ~20 Gpa.[29]

No significant differences between the bulk fill composites tested in this study regarding marginal adaptation and this in agreement with one study by Miletic et al., who found no significant difference in volumetric shrinkage and marginal integrity between five Bulk fill resin based composites including, Filtek posterior and Tetric EvoCeram.[30]

There are no significant differences in marginal adaptation among the four groups, although the difference in their chemistry.

And this can be explained by a lower Young's modulus of all bulk fill material tested that may allow stress dissipation during the polymerization process, thus reducing the stress when bigger increments are used.[31-33] also the use of universal adhesive systems in selective etching mode in all the groups. Bonding system influence on marginal adaptation was evaluated in two reports.[34, 35] It was conclude that with the application of the same adhesive system, the marginal integrity was not much influenced by either the type of filling technique or the filling material. Moreover, in one study by Koyuturk et al, who evaluated the influence of the bulk fill restorative technique on microleakage and microtensile of class II restorations, it was concluded that phosphoric acid-etching of enamel remained the most reliable method for achieving a fatigue-resistant enamel bond. [36] Recently, a systematic review including ten studies evaluated the marginal integrity of different bulk fill materials, the meta-analysis revealed no significance differences in marginal adaptation in enamel and dentin between different bulk fill composites used for class II restorations which is also comparable to that of conventional layered composite.[37] It is also important to mention that the present acceptable marginal adaptation results were obtained in the laboratory condition which provides improved light curing unit capability and good accessibility to the restored cavities. Further studies with larger sample size and class II cavities need to be tested to evaluate the potential of the newer bulk fill restorative materials.

CONCLUSIONS:

Under the limitations of this in vitro study, it was concluded that all the tested bulk fill materials showed acceptable marginal adaptation after thermocycling with no significant differences between them.

REFERENCES:

1. Cara RR, Fleming GJ, Palin WM, Walmsley AD, Burke FJ. Cuspal deflection and microleakage in premolar teeth restored with resin-based composites with and without an intermediary flowable layer. J Dent 2007; 35: 482-489.
2. Braga RR, Ferracane JL. Alternatives in polymerization contraction stress management. Crit Rev Oral Biol Med 2004; 15:176-184.
3. Ferracane JL. Buonocore lecture. Placing dental composites-a stressful experience. Oper Dent 2008; 33:247-257.
4. Alomari QD, Reinhardt JW, Boyer DB. Effect of liners on cusp deflection and gap formation in composite restorations. Oper Dent 2001; 26:406-411.
5. McCullock AJ, Smith BG. In vitro studies of cuspal movement produced by adhesive restorative materials. Br Dent J 1986; 161:405-409.
6. Lee MR, Cho BH, Son HH, Um CH, Lee IB. Influence of cavity dimension and restoration methods on the cusp deflection of premolars in composite restoration. Dent Mater 2007; 23:288-295.
7. Kwon Y, Ferracane J, Lee IB. Effect of layering methods, composite type, and flowable liner on the polymerization shrinkage stress of light cured composites. Dent Mater 2012; 28: 801-809.
8. Lazarchik DA, Hammond BD, Sikes CL et al. Hardness comparison of bulk-filled/trans tooth and incrementalfilled/occlusally irradiated composite resins. J Prosthet Dent. 2007; 98:129-40.
9. Lee MR, Cho BH, Son HH et al. Influence of cavity dimension and restoration methods on the cusp deflection of premolars in composite restoration. Dent Mater. 2007; 23:288-95.

10. Vivadent I. Tetric EvoCeram Bulk Fill. Instructions for use. Available online athttp://www.ivoclarvivadent.com/en us/composites/restorativematerials/T etric Evoceram ¬bulk-fill (accessed November 2016).
11. M Filtek TM Bulk Fill. Posterior Restorative. Technical Product Profile. Available online at http://multime¬dia.3m.com/mws/me dia/976634O/filtek-bulk-fill-posterior-restorative-technical-product-profile.pdf (accessed November 2016).
12. Garoushi S, Vallittu P, Shinya A, Lassila L. Influence of increment thickness on light transmission, degree of conversion and micro hardness of bulk fill composites. Odontology.2016; 104: 291-7.
13. Tiba, A.; Zeller, G.; Estrich, C.; Hong, A. A laboratory evaluation of bulk-fill versus traditional multi-increment-fill resin-based composites. J. Am. Dent. Assoc. 2013; 8, 13–26.
14. Mousavinasab SM, Meyers I. Fluoride release by glass ionomer cements, compomer and giomer. Dent Res J. 2009; 6:75–81.
15. Pulpdent. Activa BioActive. A closer look at bioactive materials. Third Edition, Pulpdent, Watertown, USA 2017.
16. Edson AC, Stefano A, Dorien L, Fernanda FJ, Tissiona B. Marginal adaptation of class II cavities restored with bulk-fill composites. J Dent 2014; 42:575-580.
17. Heintze SD, Monreal D, Peschke A. Marginal quality of class II composite restorations placed in bulk compared to incremental technique: Evaluation with SEM and Stereo microscope. J Adhes Dent 2015; 17:147-154.
18. Van Ende A, Mine A, De Munck J, Poitevin A, Van Meerbeek B. Bonding of low-shrinking composites in high C-factor cavities. J Dent. 2012; 40:295-303.
19. Pecie R, Onisor I, Krejei I, Bortolotto T. Marginal adaptation of direct classII composite restorations with different cavity liners. Oper Dent 2013; 38:1-11.
20. Zafar, M.S.; Amin, F.; Fareed, M.A.; Ghabbani, H.; Riaz, S.; Khurshid, Z.; Kumar, N. Biomimetic Aspects of Restorative Dentistry Biomaterials. Biomimetics 2020, 5, 30-34.
21. ActivaTM BioActive-RestorativeTM Archives—Pulpdent. Available online: https://www.pulpdent.com/shop/cate gory/activabioactive-restorative/ (accessed on 10 December 2019)
22. Yeo HW, Loo MY, Alkhabaz M, Li KC, Choi JJE, Barazanchi A. Bulk-Fill Direct Restorative Materials: An In Vitro Assessment of Their Physio-Mechanical Properties. *Oral* J. 2021; 1:75-87.
23. Nirmala Bishnoi, Ida de Noronha de Ataide, Marina Fernandes, Rajan Lambor, Bobbin Sandhu. Evaluating the marginal seal of a bioactive restorative material Activa Bioactive and two bulk fill composites in class II restorations: an in vitro study. Int J Appl Dent Sci 2020; 6:98-102.
24. Ana Raquel Benetti, Stavroula Michou, Liselotte Larsen, Anne Peutzfeldt, Ulla Pallesen & Jan Willem Viator van Dijken. Adhesion and marginal adaptation of a claimed bioactive, restorative material, Biomaterial Investigations in Dentistry, 2019; 6:90-98.

25. Kaushik M, Yadav M. Marginal microleakage properties of activa bioactive restorative and nanohybrid composite resin using two different adhesives in non-carious cervical lesions – an in vitro study. J West Afr Coll Surg. 2017; 7:1–14.

26. Owens BM, Phebus JG, Johnson WW. Evaluation of the marginal integrity of a bioactive restorative material. Gen Dent. 2018; 66:32-36.

27. Peutzfeldt A, Asmussen E. Determinants of in vitro gap formation of resin composites. J Dent. 2004; 32:109–15.

28. Braga, R.; Yamamoto, T.; Tyler, K.; Boaro, L.; Ferracane, J.L.; Swain, M.V. A comparative study between crack analysis and a mechanical test for assessing the polymerization stress of restorative composites. Dent. Mater 2012, 28, 632–641.

29. Leprince, Julian & Palin, William & Vanacker, Julie & Sabbagh, Joseph & Devaux, Jacques & Leloup, Gaëtane. Physico-mechanical characteristics of commercially available bulk-fill composites. J of Dent 2014; 8: 05-09.

30. Miletic V, Peric D, Milosive M, Manoljlovic, and Mitrovic. Local deformation fields and marginal integrity of sculptable bulk fill, low shrinkage and conventional composites. Dent Mater J.2016; 32:1441-1451.

31. Fronza BM, Rueggeberg FA, Braga RR, Mogilevych B, Soares LE, Martin AA, et al. Monomer conversion, microhardness, internal marginal adaptation, and shrinkage stress of bulk-fill resin composites. Dent Mater. 2015; 31:1542-51.

32. Ferracane JL. Resin-based composite performance: are there some things we can’t predict? Dent Mater. 2013;29: 51-8.

33. Domarecka, M.; Szczesio-Wlodarczyk, A.; Krasowski, M.; Fronczek, M.; Gozdek, T.; Sokolowski, J.; Bociong, K. A Comparative Study of the Mechanical Properties of Selected Dental Composites with a Dual-Curing System with Light-Curing Composites. Coatings 2021, 11, 1255.

34. Heintze SD, Monreal D, Peschke A. Marginal quality of class II composite restorations placed in bulk compared to an incremental technique: evaluation with SEM and stereomicroscope. J Adhes Dent 2015; 17: 147-154.

35. Roggendorf MJ, Kramer N, Appelt A, Naumann M, Frankenberger R. Marginal quality of flowable 4-mm base vs. conventionally layered resin composite. J Dent 2011; 39: 643-647.

36. Koyuturk AE, Tokay U, Sari ME, Ozmen B, Cortcu M, Acar H, et al. Influence of the bulk fill restorative technique on microleakage and microtensile of class II restorations. Pediatr Dent J 2014; 24: 148-152.

37. Gerula-Szymańska, Agnieszka et al. Marginal integrity of flowable and packable bulk fill materials used for class II restorations -A systematic review and meta-analysis of in vitro studies. Dental materials journal 2020; 39(3): 335–344.