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COMPARISON OF THE MICROLEAKAGE IN CLASS II BULK-FILL RESTORATIONS AND DIFFERENT FILLING TECHNIQUES:

AN "*IN VITRO STUDY*"

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Abstract

Keywords:

bulk-fill composite, bulk-fill composite resin, sdr composite, microleakage composite, sdr flow, microleakage sdr, bulk-fill flowable composites.

Objective

The aim of this study is to evaluate the microleakage at the interproximal horizontal margin in Class II restorations realized using four different types of composite resin: SDR® (Dentsply, Dentsply Sirona Italy – Piazza dell'Indipendenza, 11, 00185 Rome RM), Xtra-base® (VOCO, VOCO GmbH – 27457 Cuxhaven, Germany), Ceram-X™ (Dentsply, Dentsply Sirona Italy – Piazza dell'Indipendenza, 11, 00185 Rome RM), GrandioSO®(VOCO, VOCO GmbH – 27457 Cuxhaven, Germany). Additionally, two of these (SDR® and Xtra-base®) were used following a bulk fill technique following the producer's instructions, while the other two (Ceram-X™ and GrandioSO®) were used following the traditional incremental technique.

Methods

A total of 20 freshly extracted human teeth, either molar or premolars, were selected. They were randomly divided in four groups, one for each material: for each tooth, two Class II cavities, one mesial and one distal, were realized in order to be reconstructed with the material assigned to each tooth. In total, each group had five teeth and 10 restorations made, for a total of 40 restorations. After restoration, the teeth were covered with nail polish except for a 2mm-wide area which included the interproximal horizontal margin, and the apexes were sealed using Dyract®Seal sealer (Dentsply, Dentsply Sirona Italy – Piazza dell'Indipendenza, 11, 00185 Rome RM). The samples were then thermocycled at 55°C for 500 cycles and immersed in a solution of 0.2% Fuchsin dye for 24 hours. They

were then sectioned mesiodistally and examined using an optical microscope (Leica DMS 1000) at a magnification of 20x: the microleakage was assessed by measuring the dye penetration through the floor of the restoration and scored using the Demarco scale [Demarco 2001]. A Kruskal-Wallis Test and six Mann-Whitney tests were then performed to investigate whether or not the difference between the results in the different groups was statistically significant.

Results

In this study, the best performance was observed in Group 2 (Xtra-base® VOCO; Bulk Fill technique) since no signs of microleakage were noticed. In Group 1 (SDR® Dentsply; Bulk Fill technique) the worst performance was observed: five samples showed no infiltration, while the other five showed a score of 2. In group 3 (Ceram-X™ Dentsply; Incremental technique.) six samples showed a score of 0, two samples a score of 1 and two samples a score of 2. In group 4 (GrandioSO®VOCO; Incremental technique) seven samples showed a score of 0, while one sample showed a score of 1 and two samples showed a score of 2.

The Kruskal-Wallis test, however, did not reveal any statistically significant difference. Six different Mann-Whitney tests (one for each pair of groups, every combination possible) confirmed these results by not showing statistically significant differences between the different composites and techniques.

Conclusions

Within the natural limitations of an in-vitro study, there is no statistically significant difference in terms of microleakage scores, even after thermocycling, between four different composite resins (Xtra-base® VOCO, SDR® Dentsply, Ceram-X™ Dentsply, GrandioSO®VOCO) two of which used with a bulk fill technique (Xtra-base® VOCO, SDR® Dentsply) and two with an incremental technique (Ceram-X™ Dentsply, GrandioSO®VOCO), as per the manufacturer's instructions. These results encourage the design of clinical studies which could highlight differences between the performance of these composites

through time when subjected not only to intra-oral temperature variation, but to occlusal forces, pH variations and plaque accumulation too.

Introduction

Nowadays, composite resins are widely used in dentistry to directly restore cavities. One of the issues that newer composite resins attempt to solve is the polymerization contraction of the polymeric matrix, a basic component of composite resins.[1] This contraction is caused by the polymeric chain formation which pulls the monomers closer together[2] and generates forces that are transmitted to the adhesive interface between the tooth and the restoration, causing cusp deflection and gap formation. [Ishikiriama 2012]. Microleakage is a consequence of this contraction and causes secondary caries and postoperative sensitivity [Ishikiriama 2012].

Until recently, one of the techniques used to minimize polymerization contraction was the incremental technique[3] which consists in gradually building up the restoration by using two millimiter increments with polymerization between applications until the restoration is complete; the layers can be horizontal, oblique or vertical [Fig. 1-3][4]. Bulk fill composites were recently introduced in the market: they are designed in order to minimize polymerization shrinkage and to be used in four millimiter increments. [Fig. 4][14] [5]

Many authors designed studies aimed to compare bulk fill composite resins with traditional incremental technique composite resins, showing different results attributable to the different types of filler used in these composites. [6] [7] [8][9] Regarding the adhesion of composites to dental tissues, other authors used fluoride varnishes to analyse microleakages and shear bond strength of composites used for orthodontic brackets. [10] [11] [12]

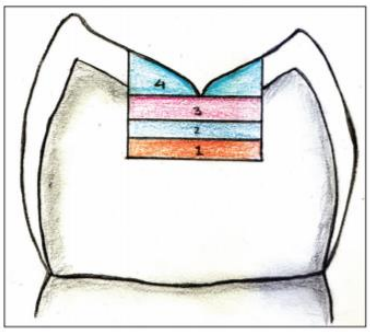

Figure 1 Horizontal Layering Technique[4].

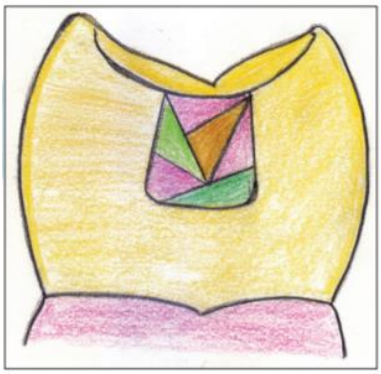

Figure 2 Oblique layering technique[4].

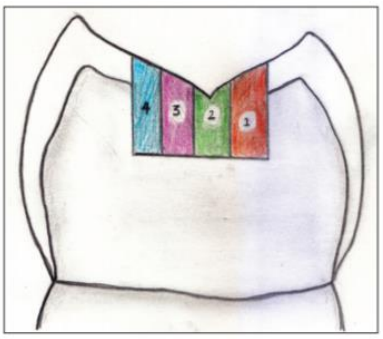

Figure 3 Vertical Layering technique[4].

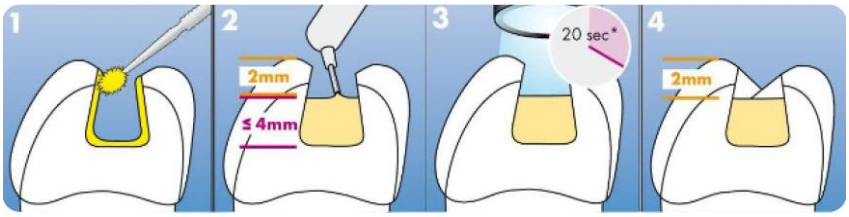

Figure 4 Bulk Fill Technique

The aim of this in vitro study is to compare the presence of microleakages in four different groups of Class II restorations on extracted teeth, using four composite resins with either the bulk-fill technique or an incremental technique, in order to determine if there is any difference between the techniques or materials. In order to better simulate the stress these restorations are subjected to in the oral cavity, all the restored teeth will be thermocycled.

Materials and Methods

For this study, a total of 20 teeth (molars and premolars) extracted for periodontal reasons were selected. The Inclusion criteria for the teeth were:

- Intact anatomical crown.
- No Fractures.
- No enamel lesions caused by trauma.

After extraction, the samples were cleaned thoroughly using a toothbrush, leaving no residual tissues on them, and stored in saline at a temperature of 4°C.

Group Assignment and Randomization

The samples were randomly divided in four different groups, one for each composite resin and corresponding technique used.

- Group 1: SDR® (Dentsply); Bulk Fill technique. [Fig. 5]
- Group 2: Xtra-base® (VOCO); Bulk Fill technique. [Fig. 6]
- Group 3: Ceram-X™ (Dentsply); Incremental technique. [Fig. 7]
- Group 4: GrandioSO®(VOCO); Incremental technique. [Fig. 8]

The specific composition of these composites can be found in TABLE I

Table I The four different composite resins used in this study.

composite	viscosity	manufacturer	Maximum increase recommended by the manufacturer	Composition according to the manufacturer's information
SDR™	*fluid*	*Densply*	*4mm*	*Barium-alumino-fluoro-borosilicate glass* *Strontium-alumino-fluoro-silicate glass* *Ethoxylated Bisphenol A dimethacrylate (EBPADMA)* *Triethyleneglycol dimethacrylate (TEGDMA)* *Camphorquinone (CQ)* *Photoinitiator* *Photoaccelerator* *Butylated hydroxyl toluene (BHT)* *UV Stabilizer* *Titanium dioxide* *Iron oxide pigments fluorescing*
Xtra-base	*fluid*	*Voco*	*4mm*	*Resin:BisGMA,BisEMA,UDMA and Procrylat filler System: Zirconia/silica with a particle size range of 0.01 to 3.5 microns (average 0.6 microns)* *-Ytterbium trifluoride particle size range of 0.1 to 5 microns.* *-Filler loading is 64% by weight (42.5% by volume)*
Ceram X®	*condensable*	*Densply*	*2mm*	*Bis-GMA,TGDMA, UDMA) and methacrylate functionalised but otherwise non-reactive fillers.*
GrandioSo	*condensable*	*Voco*	*2mm*	*Bis-GMA, Bis-EMA*

Figure 5 SDR® (Dentsply) bulk fill composite resin.

Figure 6 Xtra-base® (VOCO) bulk fill composite resin.

Figure 7 Ceram-X™ (Dentsply) composite resin.

Figure 8 GrandioSO®(VOCO) composite resin.

The randomization was carried out as follows:

1. Author 1 prepared 20 opaque envelopes containing a sheet of paper on which “Group 1 SDR – Bulk Fill”, “Group 2 Xtra-base – Bulk Fill”, “Group 3 Ceram-X – Incremental technique” or “Group 4 GrandioSO – Incremental technique” was written. 5 envelopes for each group were obtained.
2. After two II class cavities were artificially created on every tooth by Author 2, Author 3 opened one of the 20 opaque envelopes and showed the sheet of paper to Author 2, discarding it afterwards.
3. Author 2 then proceeded to restore the first tooth using the composite resin indicated by the sheet of paper and the technique suggested by the producer (either bulk fill or incremental technique).
4. For the second tooth, Author 3 opened one of the remaining 19 opaque envelopes and showed the sheet of paper to author 2, discarding it afterwards.
5. Author 2 then proceeded to restore the second tooth using the composite resin indicated by the sheet of paper and the technique suggested by the producer (either bulk fill for SDR and Xtra-base or incremental technique for Ceram-X and GrandioSO).
6. This was repeated until all the teeth were restored and divided in four groups. [Fig. 9]

The choice to prepare all the teeth before knowing which composite resin would be used was made in order to avoid conditioning of Author 2 to prepare the cavity differently based on the technique used for each composite resin, even though the operator was instructed to prepare the cavities using the same technique beforehand.

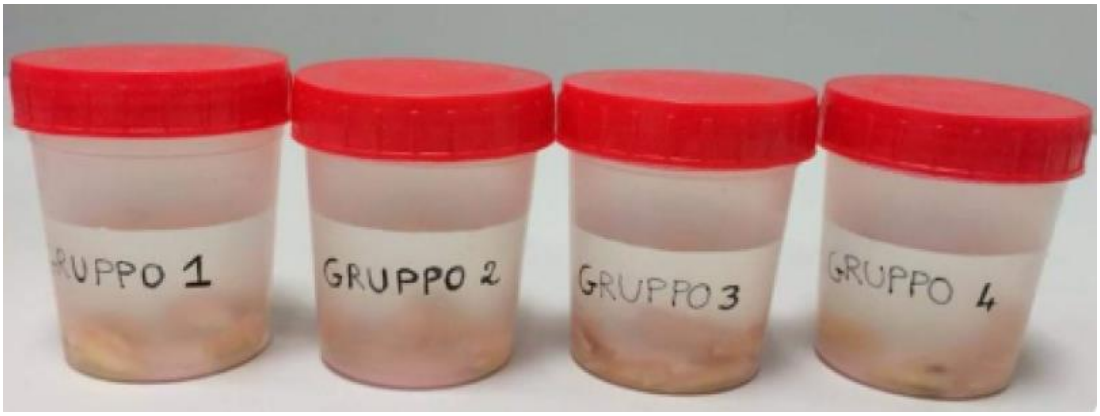

Figure 9 The four groups ready to be restored.

Sample preparation

For each sample, two class II cavity preparations were made using long round end cylinder burs. The cavities were designed to have their horizontal margin above the amelocemental junction, a mesio-distal depth of 4mm, a vestibular-lingual/palatal width of 2mm and a coronal-apical depth of 6mm. [Fig. 10-11]

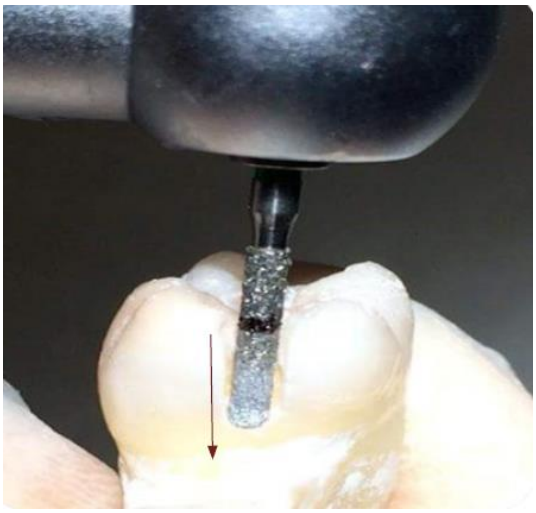

Figure 10 Cavity preparation

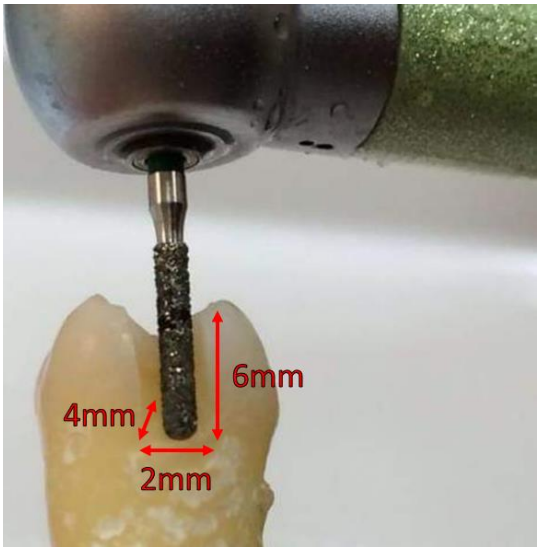

Figure 11 Sample Preparation with lengths.

Restoration procedures: cavity isolation, etching and adhesive application

The first part of the restoration procedure was identical for all the samples, regardless of which group they were assigned to.

1. The sample was isolated using an Automatrix Band System® (Dentsply) and etched using Proclinic Expert Etching Gel® (Proclinic)[Fig. 12-13]
2. After thoroughly removing the etching system using a water spray and drying the sample using an air spray, the adhesive system (Futurabond U™ – VOCO) was applied [Fig. 14], dried using an air spray then exposed to a polymerizing light (Elipar™ Led - 3M ESPE) for 20 seconds.

Figure 12 Sample Isolation.

Figure 13 Etching.

Figure 14 Adhesive system.

Restoration procedures: Bulkfill technique

After Isolation, etching and adhesive application, in Group 1 (SDR® - Dentsply) and in Group 2 (Xtra-base® - VOCO) the bulk fill technique was used to restore the two cavities on each sample [Fig.15]. Four millimetres of material were directly injected in the cavity and polymerized for 20 seconds [Fig. 16]. The remaining two millimiters were made using a nanohybrid composite using an incremental technique.

Figure 15 Bulk Fill composite resin injection.

Figure 16 Polymerization.

Restoration procedure: Incremental Technique

After Isolation, etching and adhesive application, in Group 3 (Ceram-X™ - Dentsply) and in Group 4 (GrandioSO® - VOCO) the incremental technique was used to restore the two cavities on each sample. Every two millimiters of composite applied were polymerized for 20 seconds until the cavity was filled and correctly restored.

Restoration procedure: polishing, thermocycling, sealing and cutting

After the restorations were made, they were immediately polished using disks and polishing burs. During polishing the samples were cooled under a constant stream of water. The samples were then covered with two thin coats of nail polish, leaving only a 2mm thick band which included the horizontal margin of the restoration. The apexes were sealed using Dyract®Seal sealer (Dentsply).

After all the samples were dry, they were thermocycled: each sample was submerged in cold water (5°C) for 30 seconds, then hot water (55°C) for 30 seconds for a total of 500 times.

They were then left for 24 hours at ambient temperature in four plastic jars (one for each group) containing the same solution of 0,5% Basic Fuchsine dye (Scharlau Fuchsine - Scharlab) [Fig. 17-18].

Figure 17 The four jars, one for each group.

Figure 18 The Fuchsine solution used.

The samples were cut along the sagittal axis (from mesial to distal) using a steel disk [Fig. 19] and stored at ambient temperature in four different plastic jars in order to be later observed using an optical microscope (Leica DMS 1000) with a magnification of 20x and a picture resolution of five MP.

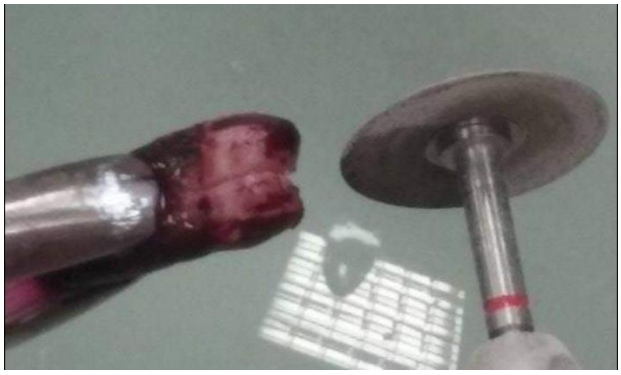

Figure 19 Sectioning of a sample using a steel disk.

Results

During observation [Fig. 20], the microleakage was evaluated using the Demarco classification[13]:

- Score 0: no microleakage
- Score 1: microleakage of the horizontal wall.
- Score 2: microleakage of the axial wall.

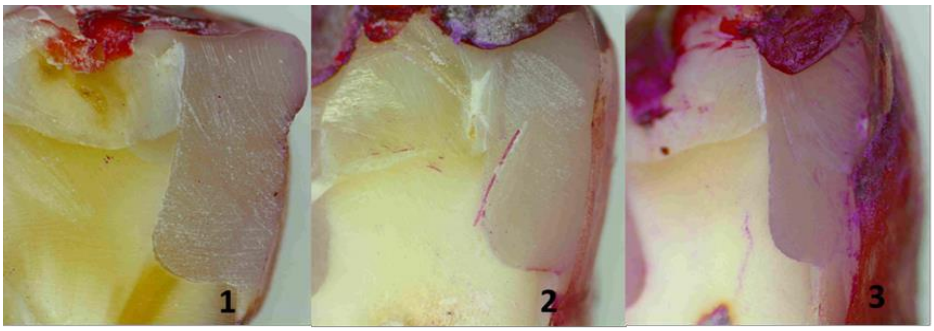

Figure 20 Example of three different restorations showing different scores for microleakage.

The results for the observations in each group can be found in TABLE II. In Group 1, five restorations showed no infiltration (score 0) while the other five showed heavy infiltration (score 2); in Group 2, all 10 restorations showed no infiltration (score 0); in Group 3, six restoration showed no infiltration (score 0) while two showed light infiltration (score 1) and two showed heavy infiltration (score 2); lastly, in Group 4, seven restoration showed no infiltration (score 0) while one showed light infiltration (score 1) and two showed heavy infiltration (score 2) [Fig. 21].

Based on the results from the Kruskal-Wallis test there is no statistically significant difference (p value = 0.21861) between the different composite resins used in this study [Table III]. Mann-Whitney U tests between the different groups also do not show any statistically significant difference.

Table II Scores for each group

Scores for each group			
	Score 0	**Score 1**	**Score 2**
Group 1	5	0	5
Group 2	10	0	0
Group 3	6	2	2
Group 4	7	1	2

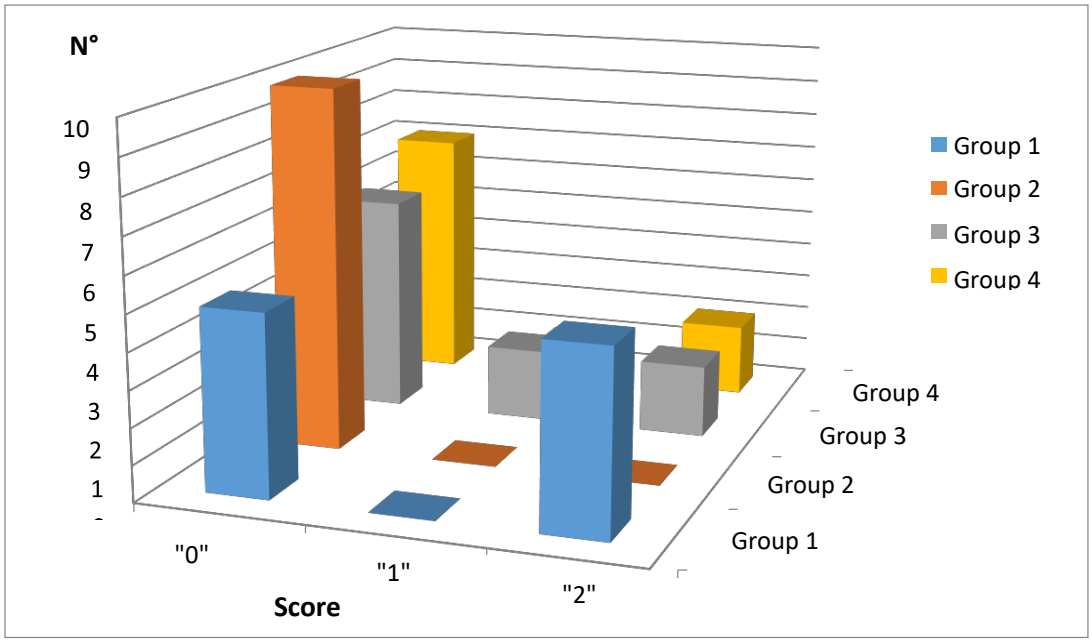

Figure 21 Scores for the different groups visualized in a graph.

Table III Kruskal-Wallis Test

Kruskall-Wallis Test			
Score	**Ranks**		
	Group	**N**	**Mean Rank**
Microleakage Score	**Group 1 SDR® (Dentsply) Bulk Fill**	10	25.25
	Group 2 Xtra-base® (VOCO) Bulk Fill	10	1.44
	Ceram-X™ (Dentsply) Incremental	10	21.9
	GrandioSO®(VOCO) Incremental	10	20.35
	TOTAL	40	

Discussion

The absence of a statistically significant difference between the microleakage scores of these four composites seems to be in contrast with the striking differences between them when the results are observed by themselves in this study.

This is justified by the anecdotal nature of the non-statistical observation of results: just because the samples in this study showed certain performances, it does not mean that this is true for every restoration performed in the same way; a second batch of samples prepared exactly in the same way as explained in this study could yield different results.

All four of these composite resins were introduced in the market recently, and their composition was designed to minimize polymerization contraction: the fact that these composites were used according to the manufacturer's instruction may have enhanced these properties, guaranteeing results which are overall acceptable and do not differ from each other.

The natural limitations of in-vitro studies should also be considered, seeing as factors like pH variation, occlusal forces and plaque accumulation were not simulated, even though sudden changes in temperature were simulated through thermocycling.

Regarding technique differences, it has been reported by the operator that Bulk-fill composites allow for a faster restoration of the cavity, while the incremental technique takes more time and its results may be influenced by the operator's experience.

Conclusions

Within the natural limitations of this in-vitro study, we can safely assume that there is no statistically significant difference in terms of microleakage scores, even after thermocycling, between four different composite resins (Xtra-base® VOCO, SDR® Dentsply, Ceram-X™ Dentsply, GrandioSO®VOCO) two of which used with a bulk fill technique (Xtra-base® VOCO, SDR® Dentsply) and two with an incremental technique (Ceram-X™ Dentsply, GrandioSO®VOCO), as per the manufacturer's instructions. These results, however, encourage the design of clinical studies which could highlight differences between the performance of these composites through time when subjected not only to intra-oral temperature variation, but to occlusal forces, pH variations and plaque accumulation too.

References

1. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res. 187 Nov; 66(11):1636-9

2. Ishikiriama SK, Valeretto TM, Franco EB, Mondelli RF. The influence of "C-factor" and light activation technique on polymerization contraction forces of resin composite. *J Appl Oral Sci*. 2012;20(6):603-6.

3. Donly KJ, Jensen ME. Posterior composite polymerization shrinkage in primary teeth: An *in vitro* comparison of three techniques. Pediatr Dent. 1986;8:209–12.

4. Chandrasekhar V, Rudrapati L, Badami V, Tummala M. Incremental techniques in direct composite restoration. J Conserv Dent 2017;20:386-91

5. Gonçalves, Flávia, Campos, Luiza Mello de Paiva, Rodrigues-Júnior, Ezequias Costa, Costa, Fabrícia Viana, Marques, Pamela Adeline, Francci, Carlos Eduardo, Braga, Roberto Ruggiero, & Boaro, Letícia Cristina Cidreira. (2018). A comparative study of bulk-fill composites: degree of conversion, post-gel shrinkage and cytotoxicity. *Brazilian Oral Research*, *32*, e17. Epub March 08, 2018.

6. Vanamala N, Srirekha A, Gururai N, Sushma R, Nagabhushana D, Vijai S. Assesment of Microleakage and dentin margins with a bulk-fill flowable resin. Eur J Dent 2014;8(1):1-8.

7. Alrahlah, A., Khan, R., Alotaibi, K., Almutawa, Z. & Fouad, H. Simultaneous Evaluation of Creep Deformation and Recovery of Bulk-Fill Dental Composites Immersed in Food-Simulating Liquids. 1–12 (2018). doi:10.3390/ma11071180.

8. Alsagob, E. I., Bardwell, D. N., Ali, A. L. A. O. & Khayat, S. G. Comparison of microleakage between bulk- fi ll fl owable and nano fi lled resin-based composites. 10, 102–109 (2018).

9. Marin B.et alii Evaluation of bulk-fill systems: microtensile bond strength and non-destructive imaging of marginal adaptation Braz. Oral Res. 2018;32:e8

10. Cossellu G., Lanteri, V. *et al.* Timing considerations on the shear bond strength of orthodontic brackets after topical fluoride varnish applications. *J. Orthod. Sci.* 6, 11 (2017).

11. Cossellu G., Lanteri V., Butera A., Sarcina M., Farronato GP. Effects of six different preventive treatments on the shear bond strength of orthodontic brackets: *in vitro* study. *Acta Biomater. Odontol. Scand.* 1, 13–17 (2015).

12. Lanteri, V., Segù, M., Doldi, J. & Butera, A. Pre-bonding prophylaxis and brackets detachment: An experimental comparison of different methods. *Int. J. Clin. Dent.* 7**,** 191–197 (2014).

13. Demarco FF, Ramos OL, Mota CS, Formolo E, Justino LM. Influence of different restorative techniques on microleakage in Class II cavities with gingival wall in cementum. Oper Dent. 2001;26(3):253–9.

14. Uehara N, Ruiz AJ, Velasco J, Ceja I, Espinosa R. Adaptaciòn marginal de las resinas bulk-fill. J Rodyb 2013;(2):1-10