Cumhuriyet Dental Journal, 25(3): 211-216, 2022
DOI: https://doi.org/10.7126/cumudj.991952

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 Available online, ISSN: 1302-5805 Publisher: Sivas Cumhuriyet Üniversitesi

The Differences of Microleakage Smart Dentin Replacement, Glass Ionomer Cement and a Flowable Resin Composite as Orifice Barrier in Root Canal Treated

Erma Sofiani[1,a,*], **Emilisa Indah Sari**[1,b]

[1]*Conservative Departement,School of Dentistry, Faculty of Medicine and Health Sciences, University Muhammadiyah Yogyakarta, Bantul, Yogyakarta 55184, Indonesia*

**Corresponding author*

Research Article

History

Received: 06/09/2021
Accepted: 10/08/2022

ABSTRACT

This study was a laboratory experiment. The sample *was 27 extracted one or two canal mandibular* premolar *teeth* consist of: a smart dentin replacement, glass ionomer cement, and a flowable resin composite. Teeth were prepared using a crown-down method and obturated using gutta percha and AH Plus. After placement of the orifice barrier with a thickness of 4 mm, the teeth were immersed in a 2% methylene blue solution at 37ºC for 24 hours. Teeth sectioned in the buccolingual direction and observation of microleakage using a stereomicroscope (M=10×). The results showed that microleakage differences between a smart dentin replacement, glass ionomer cement, and a flowable resin composite. The smart dentin replacement has the smallest microleakage value of 1.70 but does not differ significantly with the flowable composite resin.

Keywords: Dentin, Flowable Resin Composite, Glass Ionomer Cement, Microleakage, Orifice Barrier, Premolar, Root Canal

[a] *ermasofiani@umy.ac.id* *https://orcid.org/0000-0002-6146-8008*
[b] *emilisa.sari009@yahoo.com* *https://orcid.org/0000-0002-2684-1284*

How to Cite: Sofiani E, Sari EI. (2022) The Differences of Microleakage Smart Dentin Replacement, Glass Ionomer Cement and a Flowable Resin Composite as Orifice Barrier in Root Canal Treated, Cumhuriyet Dental Journal, 25(3): 211-216

Introduction

Root canal treatment is aimed at controlling bacterial infections in root canal teeth.[1] It requires adequate restoration to prevent coronal leakage that can lead to recurrent bacterial infection.[2] After root canal treatment, the teeth structure is changed as a result of the preparation procedure, and changes that occur in dentin make it difficult for clinicians to perform restoration.[3]

Microleakage of restoration material can be caused by several factors, such as changes in material dimensions due to polymerization shrinkage, thermal contraction, and water absorption.[4] Inadequate adhesion to the tooth structure due to the formation of smear layers can also be the cause of microleakage.[5] Coronal leakage due to inadequate restoration can expose the root canal to be filled by oral material fluid.[6] Root canal filling materials such as gutta-percha and sealers are unable to block the penetration of saliva and bacteria into the root canals, which can lead to recontamination and treatment failure.[7] The use of an orifice barrier is an efficient method of reducing coronal leakage in post-root canal teeth.[8]

The presence of an intra-orifice barrier will strengthen the teeth after root canal treatment because the post-root canal treatment teeth lose vitality and moisture. The intra-orifice barrier is very useful to protecting post-root canal treatment and preventing coronal leakage.[2] Coronal leakage can lead to ingress of oral fluid and invasion of bacteria into root canals that will affect the prognosis of treatment.[13] According to research by Alikhani *et al.*[9] a glass ionomer cement (GIC, 3 mm thickness) as an orifice barrier has a lower leakage rate compared to a thickness of 1 mm. According to Valadares *et al.*[10], the use of a cervical barrier or orifice with a thickness of 2–3 mm can prevent leakage and *Enterococcus faecalis* bacterial infection.

The dental material used as an orifice barrier is placed on the orifice as a second layer of protection against bacterial contamination when the restoration is disrupted. The dental materials have to be easily placed of the material by the operator, bond with the tooth structure, do not interfere with the attachment of permanent restorations, can be distinguished from tooth structure, and can close the orifice well or have low microleakage. Some dental materials that can be used as an orifice barrier are cavit, amalgam, intermediate restorative material (IRM), Super-EBA, composite resin, GIC, mineral trioxide aggregate (MTA) and calcium-enriched mixture (CEM) cement.[11]

Low microleakage is one of the criteria for a material that can be used as an orifice barrier.[12] There are ongoing studies on microleakage in the dental material used as an orifice barrier aimed at finding dental materials that have the lowest microleakage rate, to prevent saliva and bacterial contamination from entering the root canals. Composite resin-based materials can also be used as an orifice barrier; the most commonly used material is flowable composite resin, which has low viscosity so that it can penetrate difficult areas such as orifices. The composite resin has a weakness in that its large shrinkage can cause microleakage. Smart dentin replacement is a bulk fill flowable composite resin that has low shrinkage, good cavity adaptation, low modulus of elasticity, and polymerization modulators that can reduce shrinkage so that the marginal gap between the fill and restoration material is minimal.[13]

There are several studies regarding the microleakage rate of bulkfill flow composite resin materials as an orifice barrier material (3 mm thickness).[14] So far, Smart Dentin Replacement (SDR) materials have been used more for tooth restoration to replace dentin structures. Based on this problem, this study aimed to examine differences in microleakage between a SDR, GIC, and a flowable composite resin as an orifice barrier in diganti root canal treated tooth.

Material and Methods

Research design and samples

The study was an experimental laboratory experience. Samples of mandibular premolar teeth were extracted. Twenty-seven post-extraction teeth were divided into three groups to have different treatments: SDR, GIC, and flowable resin composite groups.

Preparation of dental samples

Root canals were prepared using ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) rotary files up to F2 using the crowndown technique. Based on the pre-operative radiographs, file sizes 10 and 15 are measured and pre-curved to match the anticipated full length and curvature of the root canal. The 10 and 15 hand files are utilized within any portion of the canal until they are loose and smooth. The loose depth of the 15 file is measured, and this length is transferred to the ProTaper S1 and S2 files. Then, the coronal two-thirds pre-enlarged was shaped by first utilizing S1 and then S2 prior to initing shaping procedure. The pulp chamber is filled with a full-strength solution of sodium hypochlorit (NaOCl) 2.5%, followed with a shaped file, irrigated and recapitulated with a 10 file to break up debris and move it into the solution. The next step can focus on apical one-third procedures when the coronal two-thirds of the canal is shaped. The apical one-third of the canal is fully negotiated and enlarged to at least a size 15 hand file, and the working length is confirmed and patency established. At this stage of treatment, the preparation can be finished using one or more of the ProTaper Finishing files in a “non-brushing” manner. The F2 is selected and passively allowed to move deeper into the canal in one or more passes until the terminus is reached. When the F2 achieves length, the instrument is removed, its apical flutes are inspected, and if they are loaded with dentin, then visual evidence supports the shape is cut. Then, the root canal is irrigated, recapitulated, confirmed patency, and re-irrigated to liberate debris from the canal. Then, the gutta percha were cut under the free gingival crest to a depth of 4 mm, and a SDR, a GIC, and a flowable resin composite were placed with a thickness of 4 mm (Figure 1). To see the density of the root canal filling material and the orifice barrier, a periapical radiograph was performed (Figure 2).

Microleakage Analysis

Teeth were incubated in artificial saliva at 37ºC for 24 hours and then dried. After drying, the teeth were coated in two layers of nail varnish and wax from apical to CEJ. Then, the teeth were immersed in a 2% methylene blue solution at 37ºC for 24 hours and cleaved from the bucco-lingual direction. Observation of microleaks was carried out under a stereomicroscope (M = 10×). Measurement of the amount of penetration of the dye solution from the coronal to the apical direction on a millimeter scale using the image raster 3.0 program (Figure 3).

Statistical Analysis

The data obtained in this study were quantitative data with a ratio scale. The Shapiro–Wilk test was performed to determine the normality of the data. If the significance value is $p>0.05$, then the data distribution are normal, and vice versa.

The Levene Analysis was performed to determine the data homogeneity. If the significance value is >0.05, then the data obtained are homogeneous, and vice versa. After the data were determined to be normal and homogeneous, they were processed using the parametric statistical test with one-way ANOVA test with a significance value < 0.05. The one-way ANOVA test was conducted to determine the difference in the mean (average) of μ-leakage data from each treatment group. The statistical test was continued by carrying out the post hoc test to find out which groups were different and not significantly different.

Results

The results indicated that the average penetration measurement of dye solutions in the SDR, flowable resin composite and GIC groups were 0.1709 mm, 0.1907 mm, and 0.3770 mm, respectively (Table 2).

Based on Table 3, these results indicate that there are differences in microleakage between the three treatment groups ($\alpha<0.05$). The statistical test was continued by carrying out the post hoc test to find out which group was different and not significantly different from the other two groups (Table 4).

Based on Table 3, the ratio of microleakage between the SDR group and the Flowable Resin Composite group did not differ significantly ($p>0.05$). The comparison of the microleakage of the GIC group with those of the SDR group and the flowable resin composite group indicated a significance value of 0.000 ($p<0.05$), so it can be concluded that the group has a significant difference.

Table 1. Manufacturers and chemical compositions of material used in this study

Material name	Manufacturer	Composition
Smart Dentin Replacement (SDR) 	Dentsply Sirona, Germany	SDR patented urethane dimethacrylate resin, Dimethacrylate resin, Difunctional diluent, Barium and Strontium alumino fluoro-silicate glasses, Photoinitiating System, Colorant
Esthet X Flowable Composite 	Dentsply Sirona, Germany	Resin: BisGMA, a urethane modified BisGMA-adduct, Ethoxylate BisPhenol A dimethacrylate, TEGDMA. Filler System : Barium fluoro alumino-boro silicate glass with an average particle size of 1 µm and Nanofiller silica with a particle size less than 0.02 µm
Dentine Conditioner 	GC Corporation, Japan	Distilled water 90% Polyacrylic acid 10%
Fuji IX GP capsule 	GC Corporation, Japan	Packable glass ionomer restorative with higher fluoride release and extra translucency. It contains a glass filler (Smart Glass).

Table 2. Average measurement results of dye solutions for each group

Treatment groups	N	Average (mm)	Deviation standard	Minimum	Maximum
Smart Dentin Replacement	9	0.1709	0.04320	0.12	0.25
Flowable Composite Resin	9	0.1907	0.05044	0.12	0.26
Ionomer *Cement Glass*	9	0.3770	0.13410	0.13	0.63

Table 3. The result of one-way ANOVA data of orifice barrier microleakage.

Treatment groups	Sig.
Smart Dentin Replacement *Flowable* composite Resin Ionomer cement glass	0.000

Table 4. The post hoc test results of microleakage of orifice barrier material.

(I) Treatments	(J) Treatments	Sig.
Smart Dentin Replacement	*Flowable* composite resin	.836
	Ionomer cement glass	.000
Flowable Composite Resin	*Smart Dentin Replacement*	.836
	Ionomer cement glass	.000
Ionomer Cement Glass	*Smart Dentin Replacement*	.000
	Flowable composite resin	.000

Discussion

In this study, the thickness of the material used was 4 mm, assuming that the thicker the material, the lower the microleakage. According to the research by Olmez *et al.* the coronal leakage of MTA as an orifice barrier with a thickness of 1 mm, 2 mm, 3 mm, and 4 mm. The results of this study explain that MTA with a thickness of 4 mm has the lowest leakage.[15] However, Ghulman and Gomaa reported a different result, that the thickness of the orifice barrier, 4 mm, is too thick, and this causes difficulties in the material retrieval process if the retreatment procedure is required, so that the recommended material thickness is 2–3 mm.[16] Özyürek *et al.* evaluated the microleakage of MTA Angelus, Filtek Ultimate light-cured flowable composite resin, Filtek Z250 light-cured composite resin, and SDR with an orifice barrier thickness of 3 mm. The result is that MTA Angelus and SDR materials show better leakage resistance compared to flowable composite resins and composite resins.[14]

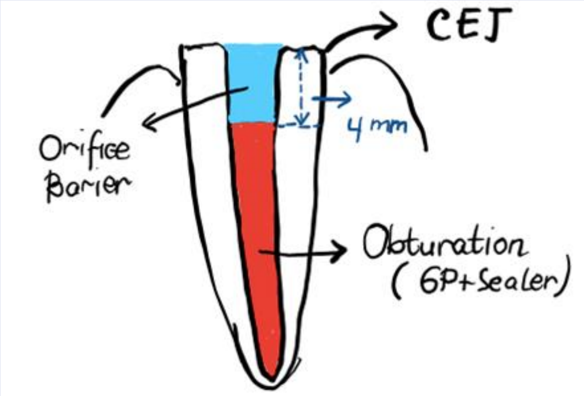

Figure 1. Illustration of orifice barrier placement.

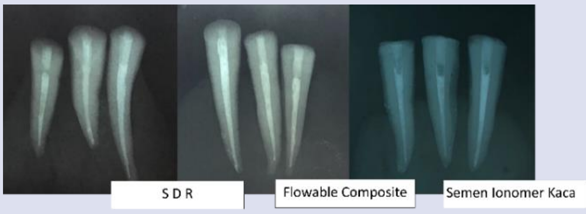

Figure 2. The post-orifice barrier application radiograph.

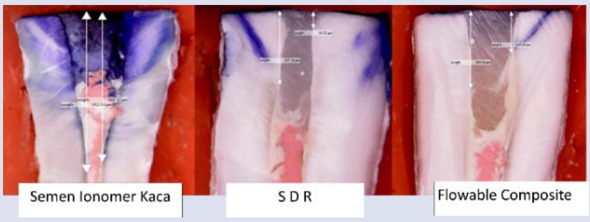

Figure 3. The result of staining dye penetration measurement of the three treatments.

Dental materials that can be used as an orifice barrier are cavit, amalgam, IRM, Super-EBA, composite resin, GIC, MTA, and CEM cement.[11] Wolcott *et al.*[12] reported that the criteria for dental materials that can be used as an orifice barrier are that the placement of the material is easy for the operator to do, binds to the tooth structure, does not interfere with the attachment of permanent restorations, is easily distinguished from the tooth structure, and has a good density to prevent microleakage.

The GIC group had the largest average microleakage value, 3.92 (Table 1), compared to those of the SDR and Flowable Resin Composite groups. The results of the post hoc test also indicated that the GIC was significantly different from the SDR and the Flowable Composite Resin. H. Yavari *et al.*[8] reported that GIC had the greatest microleakage compared to a *MTA* and a composite resin.

The microleakage of GIC in this study could be caused by the researcher not applying polyacrylic acid as a dentin conditioner properly. Polyacrylic acid is used prior to application of GIC to remove the smear layer. The smear layer formed as a result of the preparation procedure can interfere with the bonding of the ionomer cement to the tooth structure.[17] Another factor that can cause µ leakage is the GIC used in this study, which has high viscosity characteristics due to the high ratio of powder to solution and a reduction in the size of glass particles. The high viscosity results in the material not being able to flow through the entire cavity wall properly, which causes microleakage.[18]

In this study, the GIC used was GIC type II (Fuji IX GP capsule, GC Japan). GIC can bind to the tooth structure through chemical bonds between carboxylic groups in polyacrylic acid and calcium ions present in dentin. Fuji IX GP has high strontium content and can form strong bonds with tooth structures. The strontium ion in the GIC and the calcium ion in the teeth diffuse to form an ion exchange layer; this bond structure causes a strong bond between the GIC and the tooth structure.[19]

The high ratio of powder to solution in type II GIC can also improve the physical properties of the GIC.[20] The GIC for capsules can reduce the variability of the properties of GIC and avoid operator error.[21] The advantages of using a capsule preparation are not only a homogeneous ratio of powder to liquid but also good manipulation of powder and liquid using a standardized mixing machine, consistency of the liquid and predictable results.[22] In this study, the researchers experienced difficulties in the application process of GIC because the tip diameter of the capsule tip was too large to wall with the diameter of the orifice.

The SDR group had the smallest microleakage value compared to those of the other groups (Table 1). The results of the post hoc test indicated that the SDR was not significantly different from the flowable composite resin. The microleakage of the SDR was lower than that of Tetric-N-Flow. The SDR contains urethane dimethacrylate, which reduces polymerization shrinkage, so that this material experiences less microleakage than that of flowable composite resin.[23] The amount of the filler material also affects the polymerization shrinkage of the composite resin.[14] The composite flowable resin used in this study had a lower amount of filler than the SDR, so that the composite flowable resin experienced higher polymerization shrinkage and microleakage. SDR also has *self-leveling*, which allows this material to adapt well to the cavity walls.

Flowable resin composites have low viscosity characteristics so that they can flow throughout the cavity walls and can adapt well to tooth structures.[5] The micro flowable resin composite leakage is due to polymerization shrinkage due to its high matrix resin content.[24] In this study, the materials used were flowable resin composites (Esthet X Flow, Dentsply Sirona) that contained nanofiller particles that could improve the mechanical properties of the material. Esthet-X Flow has 61% of filler by weight and 53% by volume and is a type of low viscosity composites.[25] The same thing is also reinforced in the research by Poggio *et al.*[26] who found that the flowable composite resin is a material with low viscosity and stress and can thus be applied to hard-to-reach areas so that it can penetrate well.

SDR and flowable composite resin are recommended as orifice barrier materials. Those materials complete the checklist of the criteria, which include it can be placed easily, can attach to the tooth structure, and has a high density to prevent microleakage. Kumar *et al.*[13] reported that SDR has less microleakage than that of non-flowable bulk fill (Tetric Evo Ceram Bulk).

SDR is a bulk fill composite that can be applied into cavities with a thickness of 4 mm, reduces porosity, and provides a restoration with better consistency.[27] According to Leprince *et al.* SDR has better marginal adaptation[28] and micro tensile than a conventional hybrid composite resin.[2]

Micro orifice barrier leakage can cause gutta percha and a sealer to be exposed to saliva and bacteria, so it is necessary to choose a sealer that has good adhesion to the tooth structure to prevent bacterial and salivary contamination into the root canal. The use of AH Plus as a sealer provides several advantages such this material's ability to bind to the tooth structure, long working-time, ease of manipulation, and good density.[13]

The use of AH Plus (Dentsply) sealer in this study also influenced the results of the study. Different results were reported by Sauáia *et al.*[29] who conducted a study on µ leakage of a flowable composite resin, cavit, and vitremer as intra-orifice using eugenol content as a sealer. In that study, the flowable resin composite's microleakage was greater than those of cavit and vitremer. This was due to the use of sealers with eugenol content. Eugenol can penetrate into the dentin and reduce the bond strength between the tooth structure and the composite resin and interfere with the polymerization of the composite resin.

Conclusions

There are differences in microleakage of the three dental materials tested, including a SDR, a GIC, and a composite flowable resin as orifice barrier materials in post-root canal treatment teeth. The comparison of microleakage between the SDR group and the Flowable Resin Composite group indicated no significant difference. The GIC had the highest microleakage. SDR had the lowest microleakage. This requires further research on orifice barriers with various thicknesses.

References

1. Estrela C, Holland R, de Araújo Estrela CR, Alencar AHG, Sousa-Neto MD, Pécora JD, 2014. Characterization of successful root canal treatment. Braz Dent J 2014; 25: 3–11.
2. Aboobaker S, Nair BG, Gopal R, Jituri S, Veetil FRP. Effect of intra-orifice barriers on the fracture resistance of endodontically treated teeth – An ex-vivo study. J Clin. Diagnostic Res 2015; 9: ZC17–ZC20.
3. Faria ACL, Rodrigues RCS, de Almeida Antunes RP, de Mattos M, da GC, Ribeiro RF. Endodontically treated teeth: Characteristics and considerations to restore them. J Prosthodont Res. 2011; 55: 69–74.
4. Fabianelli A, Pollington S, Davidson C, Cagidiaco M, Goracci C. Scientific relevance of micro - Leakage studies. Int Dent Sa 2007; 9: 64–74.
5. Anusavice KJ. Phillip's science of dental materials. 11th ed. Elsevier: Philadelphia; 2003
6. American Association of Endodontists, 2002. Clinical and biological implications in endodontic success. [Internet]. Endod. Colleagues Excell. [updated 2002; cited 3 March 2021] Available from: https://www.aae.org/specialty/wp-content/uploads/sites/ 2/2017/07/fw02ecfe.pdf
7. Damman D, Grazziotin-Soares R, Farina AP, Cecchin D. 2012. Coronal microleakage of restorations with or without cervical barrier in root-filled teeth. Rev. Odonto Cienc 2012; 27: 208–212.
8. Yavari H, Samiei M, Eskandarinezhad M, Shahi S, Aghazadeh M, Pasvey Y. An in vitro comparison of coronal microleakage of three orifice barriers filling materials. Iran Endod J 2012; 7: 156–160.
9. Alikhani A, Babaahmadi M, Etemadi N. Effect of intracanal glass-ionomer barrier thickness on microleakage in coronal part of root in endodontically treated teeth: An in vitro study. J Dent (Shiraz, Iran) 2020; 21: 1–5.
10. Valadares MA, Soares JA, Nogueira CC, Cortes MI, Leite ME, Nunes E, Silveira FF. The efficacy of a cervical barrier in preventing microleakage of *Enterococcus faecalis* in endodontically treated teeth. Gen Dent 2011; 59: e32-37.
11. Yavari HR, Samiei M, Shahi S, Aghazadeh M, Jafari F, Abdolrahimi M, Asgary S. Microleakage comparison of four dental materials as intra-orifice barriers in endodontically treated teeth. Iran Endod J 2012; 7: 25–30.
12. Wolcott JF, Hicks ML, Himel VT. Evaluation of pigmented intraorifice barriers in endodontically treated teeth. J Endod 1999; 25: 589–592.
13. Kumar G, Tewari S, Sangwan P, Tewari S, Duhan J, Mittal S. The effect of an intraorifice barrier and base under coronal restorations on the healing of apical periodontitis: a randomized controlled trial. Int Endod J 2020; 53: 298–307.
14. Özyürek T, Özsezer-Demiryürek E, Demiroğlu M, Sari ME. Evaluation of microleakage of different intraorifice barrier materials in endodontically treated teeth. J Dent Appl Open 2016; 3: 333–336.
15. Olmez A, Tuna D, Ozdoğan YT, Ulker AE. The effectiveness of different thickness of mineral trioxide aggregate on coronal leakage in endodontically treated deciduous teeth. J Dent Child 2008; 75: 260–263.
16. Ghulman MA, Gomaa M. 2012. Effect of intra-orifice depth on sealing ability of four materials in the orifices of root-filled teeth: An ex-vivo study. Int J Dent 2012; 2012: 318108
17. Tanumiharja M, Burrow MF, Tyas MJ. Microtensile bond strengths of glass ionomer (polyalkenoate) cements to dentine using four conditioners. J Dent 2000; 28: 361–366.
18. Singla T, Pandit IK, Srivastava N, Gugnani N, Gupta M. An evaluation of microleakage of various glass ionomer based restorative materials in deciduous and permanent teeth: An in vitro study. Saudi Dent J 2011; 24: 35–42.
19. Sidhu S, Nicholson J. A review of glass-ionomer cements for clinical dentistry. J Funct Biomater 2016; 7: 16.
20. Mount GJ. An Atlas of Glass-Ionomer Cements. 13th ed. UK: Martin Dunitz Ltd.; 2002.
21. Upadhya NP, Kishore G. Glass ionomer cement - The different generations. Trends Biomater Artif Organs 2005; 18: 158–165.
22. Noort RV. Introduction to Dental Materials. 3rd ed. Philadelphia: Elsevier; 2007.
23. Marurkar A, Satishkumar KS, Ratnakar P. An in vitro analysis comparing micro leakage between smart dentin replacemet and flowable composite, when used as a liner under conventional composite. Eur J Pharm Med Res 2017; 4: 694–698.

24. Baroudi K, Rodrigues JC. Flowable resin composites: A systematic review and clinical considerations. J Clin Diagnostic Res 2015; 9: ZE18–ZE24.

25. Gallo JR, Burgess JO, Ripps AH, Walker RS, Maltezos MB, Mercante DE, Davidson JM. Three-year clinical evaluation of two flowable composites. Quintessence Int (Berl) 2010; 41: 497–503.

26. Poggio C, Dagna A, Chiesa M, Colombo M, Scribante A. Surface roughness of flowable resin composites eroded by acidic and alcoholic drinks. J Conserv Dent JCD 2012; 15: 137–140.

27. Farahanny W, Dennis D, Aruldas MD. Fracture resistance of various bulk fill composite resin in endodontically treated class I premolar (An in-vitro study). J Evol Med Dent Sci 2017; 6: 5168–5171.

28. Leprince JG, Palin WM, Vanacker J, Sabbagh J, Devaux J, Leloup G. Physico-mechanical characteristics of commercially available bulk-fill composites. J Dent 2014; 42: 993–1000.

29. Sauáia TS, Gomes BPFA, Pinheiro ET, Zaia AA, Ferraz CCR, Souza-Filho FJ. 2006. Microleakage evaluation of intraorifice sealing materials in endodontically treated teeth. Oral Surgery Oral Med Oral Pathol Oral Radiol Endodontology 2006; 102: 242–246.