

Bulk fill composites in dentistry- A review

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Abstract

Resin based composite is the most accepted material for the restoration of decayed tooth. To improve the composite material in physical, clinical, as well as to facilitate manipulation technique various modifications have been done in its structure.

Polymerization shrinkage stress, being its major drawback which affects the core of the filling and its bonding with tooth structure. This polymerization shrinkage would lead to numerous clinical consequences such as poor marginal adaptation, resulting into microleakage, development of secondary caries and subsequent pulpal inflammation. Another drawback being reduction in degree of conversion which affects the physical properties and increases the monomer proportion, which could lead to post operative sensitivity and early failure of composite filling.

Bulk fill composite is recently introduced as an advancement in resin based restoration which claims to overcome the drawback of conventional composite.

Therefore the review of this literature could be a helpful for dentists to use these new promising restorative materials with long term clinical outcome.

Keywords: Bulk fill composite, Depth of cure, Degree of conversion, Surface hardness.

Introduction

Composite resin has gained a high degree of success in the restoration of decayed and stained teeth. Nowadays, composites have become the material of choice for direct restorations on posterior and anterior teeth, due mainly to their good esthetic properties, appropriate mechanical properties, and low cytotoxicity.^{1,2} But polymerization shrinkage stress which affects the integrity of the tooth/restoration interface, being its major drawback.^{3,4}

Several alternatives have been proposed to reduce polymerization stress like modulating the light curing mechanism such as the use of alternative photoactivation methods like pulse-delay or low irradiance,⁵ low-modulus liners,⁶ and the use of incremental filling techniques.⁷ The use of incremental filling is recommended for conventional light-activated composites, with the insertion and photoactivation of increments no thicker than 2 mm. This protocol serves two purposes- reduces polymerization stress and providing homogeneous degree of conversion throughout the material thickness.⁸ The other factor which affects physical properties of composite, is its degree of conversion which in turn increases monomer proportion.⁹ This could lead to postoperative sensitivity resulting to early failure of the composite filling.¹⁰

Bulk-fill composite is recently introduced resin based material. It is considered as an advancement in the resin based restorations with claims to cure till 4 mm thickness. It could reduce the working time to approximately half of that in the conventional composite. Bulk-fill composite can be divided into flowable bulk-fill composite and non-flowable (paste-like) bulkfill composite. Flowable bulk-fill composite was initially used as injectable material.¹¹

Various modifications have been introduced in the material to overcome the above mentioned drawbacks of

composite and to allow for bulk placement of material, including:

1. Lower filler content in flowable materials;
2. To improve light transmission in depth, modification in type of filler;
3. More efficient photoinitiators with high quantum yield;
4. Modifications in the chemistry of monomer system to allow for stress relief during curing.

The rationale in using lower filler content is that it would decrease the light scattering through material and provide a better degree of conversion depth. More efficient photoinitiators are used that is germanium based photoinitiator, which present a much higher quantum yield than camphorquinone amine system and also forms 2 factive radicals, which facilitate propagation of reactive species, even at depths where intensity of light is diminished. The technology allied with other high molecular weight monomers in their chemistry have been shown to reduce polymerization stress than conventional composite. The first products of flowable composite had more resin matrix and less filler content in comparison to paste-like bulkfill composite, so it was used as a lining layer. The last products of flowable bulk-fill composite such as Venus Bulk fill (VBF; Heraeus Kulzer GmbH, Hanau, Germany) and Surefil SDR Flow (SDR; Dentsply Caulk, Milford, DE, USA) have higher filler content and improved physical properties (Ikeda et al., 2009). In other hand, the recently introduced, bulkfill Paste-like composite such as Tetric N-Ceram Bulkfill (TBF; Ivoclar Vivadent, Schaan, Liechtenstein) doesnot need a capping layer required for their flowable counterparts.¹²

Properties

The properties of different bulk fill composite have been discussed under the following headings.

Depth of cure

Various studies were conducted to assess the depth of cure for flowable bulk fill composite. The mean depth of cure of flowable bulk fill composite ranged from 2.76 mm to 10.05 mm^{13,14} Overall the depth of cure for flowable bulk fill composite was found higher than that for conventional composite.

The depth of cure for paste like bulk fill composite was also assessed in different studies and it was found that mean depth of cure ranged between 2.90 - 3.82 mm, while in other study it was found that the mean depth of cure ranged from 3.14 in light beam cure to 4.19 mm in middle beam cure. The depth of cure was comparable to that of conventional composite in one study while found a higher depth of cure in paste-like composite than that of conventional composite in other.^{13,14}

Degree of conversion (DC)

The degree of conversion for flowable bulk fill composite was assessed in different studies. Degree of conversion was found high, where they were dependent on the studied thicknesses and time after curing. When based on thickness mean % of DC ranged from 56.53 to 73.46 in 0 mm thickness, from 43.69(5.92) to 76.32(1.27) in 2 mm thickness, and from 52.04(12.45) to 80.07(2.76) in 4 mm thickness. When based on time after curing, mean %, immediately after curing ranged from 49.5 to 62.0, while at 24 hours after curing, mean % ranged from 50.9 to 79.2^{15,16} So, as per first study % DC of flowable bulk fill composite was comparable with that of conventional flowable composite and higher than that of conventional condensable composite, while other study found lower means % of DC in flowable bulk fill composite than that of conventional composite.^{15,16} Also, one more study found a high range of mean % DC of (77.3 - 80.0),¹⁴ while other studies found lower mean % DC with range from 43.6 to 71.2.^{17,18,19} For paste-like bulk fill composite, the mean % of DC when dependent on studied thicknesses was as follows: 67.45(6.58) in 0 mm, 63.00(3.88) in 2 mm, and 63.40(4.37) in 4 mm. Therefore it was concluded that the mean % of DC in paste like bulk fill composite was lower than that of conventional flowable composite at 0mm, higher than that of conventional flowable at 2 mm and lower than conventional flowable at 4mm. Although, the percentages of DC of paste-like bulk fill composite at all studied thicknesses was higher than those found in condensable conventional composite. Also, in few more studies in regard to paste-like bulk fill composite found a range of mean % of DC from 56.7 to 76.5, while in some other found a lower mean % of DC of 48.4.^{18,20,21}

Polymerization shrinkage

The polymerization shrinkage of flowable bulk fill composite as assessed by various studies, no considerable

variation was observed between the findings of these studies. For flowable bulk fill composite the mean percentage of polymerization shrinkage was found ranging from 2.76 to 4.4. A higher mean percentage of polymerization shrinkage in flowable bulk fill composite was observed than that of the conventional composite,^{13,22} while polymerization shrinkage of flowable bulk fill composite was comparable to that of conventional flowable composite in some other study but higher than that of conventional condensable composite.¹⁵

The polymerization shrinkage of paste-like bulk fill composite as assessed by five studies, there also no significant variation was observed between the findings of these studies. The mean percentage of polymerization shrinkage in paste-like bulk fill composite was observed to be ranging from 90 to 2.63. A higher mean percentage of polymerization shrinkage in paste-like bulk fill composite than that in the conventional composite was reported^{23,13} while lower to that of conventional flowable composite and comparable with that of conventional condensable composite.¹⁵

Polymerization stresses

The polymerization stress of flowable bulk fill composite was assessed in various studies. A high level of polymerization stress, where mean stress (MPa) of flowable bulk fill composite ranging from 1.68 to 2.24 was observed²² while mean of polymerization stress ranging from 1.07 to 1.65 was reported. All these studies obtained the polymerization stress of flowable bulk fill composite to be lower than that of conventional composite.^{15,24}

A high level of polymerization stress for paste-like bulk fill composite, was observed where mean stress (MPa) ranging from 2.36 to 2.42 while the mean (sd) of polymerization stress from 1.07 to 2.135 was reported in some other studies but was observed to be lower than that of conventional composite.^{15,24}

Surface hardness

In many of the studies surface hardness was assessed at different depths-top surface and at the bottom surface, few studies assessed surface hardness after ethanol storage of fillings, and few study assessed it at enamel and dentine levels.^{12,15,16,18,19,20,24-27,29-31}

The mean of top surface hardness of flowable bulk fill composite that measured in (N/mm²) at surface, 2 mm, 4mm, and 6 mm depths were assessed. They were as follows: from 34.3 to 82.3 at top surface, from 21.6 to 64.6 at 2 mm depth, from 23.5 to 61.0 at 4 mm depth, and from 25.7 to 58.9 at 6 mm depth. After storage in ethanol, the top hardness of flowable bulk fill composite was noticed to diminish to a range of 6.3 to 22.8 due to softening effect of ethanol.¹⁶ The maximum mean top hardness of flowable bulk fill composite was 120.4.²⁷ Lower top hardness of flowable bulk fill composite in comparison to conventional composite was reported in most of the studies.^{12,15,16,18,24-26,30,31} According to the depth of assessment, in regards to paste-like composite, the mean of top surface hardness for

paste-like bulk fill composite that measured in (N/mm²) at surface, 2 mm, 4mm and 6 mm depths were reported. They were as follows: from 64.52(2.45), to 144.7(18.2) at top surface, from 60.55(3.53) to 126.8(7.6) at 2 mm depth, from 41.92(4.46) to 144.3(6.2) at 4 mm depth, and from 57.7(5.4) to 129.8(3.6) at 6 mm depth.^{12,15,16,18,24-26,30,31} Lower levels of top hardness ranging from 48.54 to 91.^{15,19,20,30,31}

A high levels of top surface hardness was found 128.4 and 133.5.^{19,20,27} The findings of included studies were contradicting in comparison with the conventional composite. In some studies lower top surface hardness of paste-like bulk fill composite was reported in comparison to conventional composite^{16,21} while the top surface hardness was reported comparable in paste like bulk fill and conventional composite in some studies.^{15,24,26,30} Top hardness higher than conventional at 6 mm depth only, while in other study it is higher in paste-like in all studied depths.^{12,31}

The top hardness higher in paste-like bulk fill composite in comparison to conventional flowable composite in all studied depths, but lower than conventional condensable composite in all depths.¹⁵

Surface hardness (bottom surface)

The bottom surface hardness of flowable bulk fill composite was also assessed by different studies.^{19,20,12,31,24} The mean bottom surface hardness of 80.6 was observed in HV (N/mm²) at 40 seconds of curing and 0 distance of light tip.^{19,20} The mean of bottom surface hardness ranging from 17.0 to 21.5 at 2 mm, from 16.6 to 21.1 at 3 mm, from 15.6 to 19.8 at 4 mm, and from 13.5 to 19.4 at 5 mm.³¹ A higher range of mean bottom surface hardness of 34.31 -44.27 that was comparable with bottom surface hardness in conventional composite.²⁴ Flury et al. reported the bottom hardness of flowable bulk fill composite lower than that of conventional composite,¹² while lower bottom hardness in flowable bulk fill composite than that in conventional composite at 2 mm depth and comparable with conventional at 3 mm depth.³¹

The bottom surface hardness of paste-like bulk fill composite, was also assessed by different studies. The highest level of mean bottom surface hardness of 73.3 in HV (N/mm²) at 40 seconds of curing and 0 distance of light tip.^{19,20} A high range of mean bottom hardness of 63.61 to 68.66 was reported in one study²¹ while the lowest mean of bottom surface hardness reached 23.75.²⁶ In comparison to conventional composite, the findings were also contradicting. A higher bottom surface hardness in paste-like bulk fill composite than that in conventional composite, was reported in some studies.^{24,31}, lower and comparable bottom hardness in paste-like composite rather than in conventional composite.^{21,26}

Flexure (transverse) strength

The flexure (transverse) strength of flowable bulk fill composite, as assessed by different studies.^{29,24,19,20,18} In most of these studies, high flexural strength (in MPa) were reported ranging from 76.0¹⁸ to 139.4^{19,20} A lower levels of

flexural strength in flowable bulk fill composite was found when compared to conventional.^{18,24} The flexural strength of paste-like bulk fill composite was found to be (94.5 - 140.3) of which mean flexural strength was comparable with conventional composite.¹⁸

Compressive strength

The compressive strength of flowable bulk fill composite ranged from 182.3 to 245.1 of which mean compressive strength was lower than that in conventional composite.

The compressive strength of paste-like bulk fill where mean of compressive strength was reported to be 213.3 which was lower than that in conventional composite.²⁵

Tensile strength

The tensile strength of flowable bulk fill composite that ranged from 38.6 to 43.5 of which mean tensile strength was found lower than that in conventional composite.

The tensile strength of paste-like bulk fill composite of which mean of tensile strength was found to be 37.8 (7.7) Mps, and it was lower than that in conventional composite.²⁵

Bond strength to dentine

The bond strength to dentine in flowable bulk fill composite. at different depths was assessed (2, 4, and 6 mm)¹²

The median bond strength to dentine measured in Mpa was ranging from 21.4 to 24.6 at 2 mm, from 20.3 to 22.7 at 4 mm and from 22.0 to 23.4 at 6 mm. The bond strength in flowable bulk fill composite was observed comparable at 2 mm and higher than conventional composite at 4 and 6 mm.¹²

Marginal adaptation

The marginal adaptation of flowable bulk fill composite in which median of marginal gap in micrometer was ranging from 6.1 to 10.2. For paste-like composite, gap ranged from 6.6-7.1 micrometer. Conventional composite was not compared in the study.¹³

Micro-leakage

For assessment of the micro-leakage generally the following scores are there, score 0 = no micro-leakage, score 1 = Leakage involving 1/2 length of occlusal/gingival walls, score 2 = Leakage in more than 1/2 length of occlusal/gingival walls, score 3 = Leakage that covers entire length of occlusal/gingival walls and also involves the axial wall. The micro-leakage of flowable bulk fill composite, using these scores was reported 86.7% - 93.3% of studied specimens showing no micro-leakage while 3.3% was in score 1, 3.3% - 6.7% in score 2 and 0.0% - 3.3% in score 3, while studying micro-leakage in enamel and dentine with clearfil bonding agent, observed, higher levels of micro-leakage than those found by previous study.^{32,33} 56% of enamel specimen and 75% of dentinal specimens, reported no micro-leakage while 25% of both enamel and dentinal specimens reported score 1 microleakage, 19% of enamel

specimens only reported Score 2 micro-leakage and no specimen reported score 3 micro-leakage. The enamel micro-leakage in flowable bulk fill composite was found comparable to conventional at score 0, lower than conventional at score 1, higher than conventional in score 2 and equal at score 3. Although, the dentine micro-leakage was higher than conventional at score 0, equal at score 1 and 3, lower than conventional at score 2.

The microleakage for paste-like, using dye penetration and found 73% - 90% of studied specimens showed no micro-leakage which was lower than flowable bulk fill composite. 3.3% 23.3% of studied samples showed score 1 micro-leakage while only 0.0%-6.6% of studied samples showed score 2 and 3. Conventional composite was not compared in these studies.³³

Conclusion

In comparison to conventional composite the curing depth of flowable and paste-like composite was observed higher while degree of conversion of flowable was contradicting when compared to conventional, although paste like bulk fill was higher than condensable conventional composite. Polymerization shrinkage is higher or comparable in flowable bulk fill composite in comparison to that in the conventional composite, while in paste like composite the results was contradicting. Flowable and paste-like bulk fill reported lower polymerization stress than that of conventional composite.

In most of studies, top hardness was observed lower in flowable bulk fill composite in comparison to conventional composite, but the result was contradicting in paste like composite. In case of flowable bulk fill composite, the bottom surface hardness was comparable or lower than that in conventional composite, but the result was contradicting in case of paste like composite.

The flexure (transverse) strength of flowable bulk fill composite was reported lower than conventional composite, while in paste like composite it was comparable with conventional composite. The tensile strength and compressive strength of both flowable and paste like bulk fill composite was lower than that of conventional composite. The bond strength with dentine in case of flowable bulk fill composite was reported comparable or higher than conventional depending upon increase in thickness, while the bond strength of paste-like composite has not been assessed. No comparison was made to the conventional composite for assessing marginal adaptation. The flowable bulk fill composite was comparable to the conventional composite in terms of enamel micro leakage, but lower than conventional in dentine. No comparison made between paste like composite and conventional composite.

Therefore, the bulk fill composite (either flowable or paste-like) presented superior chemical curing properties than the conventional composite but was inferior in terms of mechanical properties (flowable bulk fill), while the results were contradicting for paste-like bulk fill composite. The

clinical studies with these materials are still very scarce and more studies are still required to elaborate this area.

Conflict of Interest: None.

References

1. Ferracane JL. Resin composite: state of the art. *Dent Mater* 2011;27(1):29-38. <https://doi.org/10.1016/j.dental.2010.10.020>
2. Marigo L, Spagnuolo G, Malara F, Martorana GE, Cordaro M, Lupi A et al. Relation between conversion degree and cytotoxicity of a flowable bulk-fill and three conventional flowable resin-composites. *Eur Rev Med Pharmacol Sci* 2015;19(23):4469-4480.
3. Gonçalves F, Azevedo CL, Ferracane JL, Braga RR. BisGMA/TEGDMA ratio and filler content effects on shrinkage stress. *Dent Mater* 2011;27(6):520-526. <https://doi.org/10.1016/j.dental.2011.01.007>
4. Han SH, Sadr A, Tagami J, Park SH. Internal adaptation of resin composites at two configurations: influence of polymerization shrinkage and stress. *Dent Mater* 2016;32(9):1085-94. <https://doi.org/10.1016/j.dental.2016.06.005>
5. Pecie R, Onisor I, Krejci I, Bortolotto T. Marginal adaptation of direct class II composite restorations with different cavity liners. *Oper Dent* 2013;38(6):E210-20. <https://doi.org/10.2341/12-229-L>
6. Gonçalves F, Calheiros FC, Witzel MF, Kawano Y, Braga RR. Effect of photoactivation protocol and radiant exposure on monomer conversion and flexural strength of a resin composite after water and ethanol storage. *J Biomed Mater Res B Appl Biomater* 2007;82(1):89-92. <https://doi.org/10.1002/jbm.b.30708>
7. Park J, Chang J, Ferracane J, Lee IB. How should composite be layered to reduce shrinkage stress: incremental or bulk filling? *Dent Mater* 2008;24(11):1501-1505. <https://doi.org/10.1016/j.dental.2008.03.013>
8. Lazarchik DA, Hammond BD, Sikes CL, Looney SW, Rueggeberg FA. Hardness comparison of bulk-filled/transmucosally irradiated composite resins. *J Prosthet Dent* 2007;98(2):129. [https://doi.org/10.1016/S0022-3913\(07\)60046-8](https://doi.org/10.1016/S0022-3913(07)60046-8)
9. IDRIS, S., ABDULJABBAR, T., HABIB, C. & OMAR, R. Factors associated with microleakage in Class II resin composite restorations. *Oper dent* 2007;32: 60-66.
10. Briso, A. L. F., Mestreneur, S. R., Delicio, G., Sundfeld, R. H., Bedran-Russo, a., DE Alexandre et al. Clinical assessment of postoperative sensitivity in posterior composite restorations. *Oper dent* 2007;32:421-426.
11. Labella, R., Lambrechts, P., Van Meerbeek, B. & Vanherle, G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. *Dent Mater* 1999;15:128-137.
12. Flury, S., Peutzfeldt, A. & Lussi, A. Influence of increment thickness on microhardness and dentin bond strength of bulk fill resin composites. *Dent Mater* 2014;30:1104-1112.
13. Benetti, A., Havndrup-Pedersen, C., Honoré, D., Pedersen, M. & Pallesen, U. Bulk-fill resin composites: polymerization contraction, depth of cure, and gap formation. *Oper dent* 2015;40:190-200. 13.
14. LI, X., Pongprueksa, P., Van Meerbeek, B. & DE Munck, J. Curing profile of bulk-fill resin based composites. *J dent* 2015; 43:664-672.
15. Zorzin, J., Maier, E., Harre, S., Fey, T., Belli, R., Lohbauer et al. A. & Taschner, M. Bulk-fill resin composites: polymerization properties and extended light curing. *Dent Mater* 2015;31:293-301.
16. Alshali, R. Z., Silikas, N. & Satterthwaite, J. D. Degree of conversion of bulk-fill compared to conventional resin-

- composites at two time intervals. *Dent Mater* 2013;29:e213-e217.
17. Guo, Y., Landis, F. A., Wang, Z., Bai, D., Jiang, L. & Chiang, M. Y. Polymerization stress evolution of a bulk-fill flowable composite under different compliances. *Dent Mater* 2016;32:578-586
 18. Leprince, J. G., Palin, W. M., Vanacker, J., Sabbagh, J., Devaux, J. & Leloup, G. Physico-mechanical characteristics of commercially available bulk-fill composites. *J dent* 2014;42:993-1000.
 19. Ilie, N., Bucuta, S. & Draenert, M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. *Oper dent* 2013a;38: 618-625.
 20. ILIE, N., Keßler, A. & DURNER, J. Influence of various irradiation processes on the mechanical properties and polymerisation kinetics of bulk-fill resin based composites. *J Dent* 2013b.;41:695-702.
 21. ABED, Y., SABRY, H. & ALROBEIGY, N. Degree of conversion and surface hardness of bulk-fill composite versus incremental-fill composite. *Tanta Dent J* 2015;12:71-80.
 22. Kim, R. J.-Y., Kim, Y.-J., Choi, N.-S. & LEE, I.B. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. *J dent* 2015;43:430-439.
 23. Mulder, R., Grobler, S. R. & Osman, Y. I. Volumetric change of flowable composite resins due to polymerization as measured with an electronic mercury dilatometer. *Oral Biol Dent* 2013; 1: 1.
 24. EL-Damanhoury, H. & Platt, J. Polymerization shrinkage stress kinetics and related properties of bulk-fill resin composites. *Oper dent* 2014;39:374-382.
 25. Rosatto, C., Bicalho, A., Verissimo, C., Bragança, G., Rodrigues, M., Tantbirojn, D et al. Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. *J dent* 2015;43:1519-1528.
 26. Jang, J., Park, S. & Hwang, I. Polymerization shrinkage and depth of cure of bulk-fill resin composites and highly filled flowable resin. *Oper dent* 2015;40:172-180.
 27. Yousef, M. K., Reem, A. I. A. E. N. & Ajaj, A. 2015. Effect of Different Light-Curing Units on Microhardness of Different Bulk Fill Materials. *Life Sci J* 12.
 28. Alrahlah, A., Silikas, N. & Watts, D. Post-cure depth of cure of bulk fill dental resin composites. *Dent Mater* 2014;30:149-154.
 29. Czasch, P. & ILIE, N. In vitro comparison of mechanical properties and degree of cure of bulk fill composites. *Clin Oral Investigations* 2013;17: 227-235.
 30. BUCUTA, S. & ILIE, N. Light transmittance and micro-mechanical properties of bulk fill vs. conventional resin based composites. *Clin Oral Investigations* 2014; 18: 1991-2000.
 31. Garcia, D., Yaman, P., Dennison, J. & Neiva, G. Polymerization shrinkage and depth of cure of bulk fill flowable composite resins. *Oper dent* 2014;39:441-448.
 32. Arslan, S., Demirbuga, S., Ustun, Y., Dincer, A. N., Canakci, B. C. & Zorba, Y.O. The effect of a new-generation flowable composite resin on microleakage in Class V composite restorations as an intermediate layer. *J Conserv Dent* 2013;16:189.
 33. Orłowski, M., Tarczydło, B. & Chalas, R. 2015. Evaluation of marginal integrity of four bulk-fill dental composite materials: In Vitro Study. *Sci World J* 2015.

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