An In Vitro Study Comparison of the Sealing Ability of High-Viscosity Bulk-Fill Resin Composites in Comparison with the Incremental Placement Technique

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Abstract: ***Background**: Actually Resin-based composites present one of the most used restorative materials. Volumetric shrinkage due to polymerization is the most debilitating problem .Thus may result in contraction stress and subsequent microleakage and adhesion failure. Incremental layering technique has been adopted as a placement technique, in order to combat polymerization shrinkage. But this technique has certain disadvantages such as difficulty in placement of increments in small cavities, increased operational time, , interlayer contamination, incorporation of voids and difficulty in maintaining isolation. .In order to reduce the time and effort needed for layering when placing posterior composites, a novel restorative approach was appeared based on the use of high-viscosity bulk-fill composites. This technique can eliminate the possibility of voids between the layers enabling up to 4 mm increments to be cured in one step, without negatively affecting polymerization shrinkage kinetics and macromechanical properties. **Aim**: The aim of this in vitro study is to compare and to analyze the sealing ability of High-viscosity bulk-fill composites in comparison to incremental posterior resin composite in posterior classII restorations with the dye penetration test. **Material and Methods**: Seventy six classII cavities were prepared on the mesial and surfaces of 38 extracted human permanent molars, which were randomly divided into two groups: G1 (38 cavities) restorated with Single Bond 2+Reflectys TM (Itena) composite resin, G2 (38 cavities) restorated with +Single Bond2+bulk fill composite resin, The samples were then subjected to thermocycling, followed by the dye penetration test. The teeth were embedded in acrylic resin and sectioned through the restorations. The results were expressed as ordinal scores from 0 to 3 at cervical, interfacial, and enamel margins. Statistics were done with SPSS20.0 software, Student t-Test and Khi-square tests were performed. The result was considered significant at p<0.05. **Results** :There were statistically significant differences between the high viscosity bulk fill resin and group and the Reflectys (Itena) composite resin in cervical and occlusal enamel interface (p0.016..) .this difference was not observed in the enamel and the interfacial regions for both groups. **Conclusion**: Within the limitations to this in vitro study, a significant scores were obtained with bulk-fill nanocomposite, thus material used clinically may be able to substitute the time-consuming incremental technique.***

1. Introduction

Actually Resin-based composites present one of the most used restorative materials. Volumetric shrinkage due to polymerization is the most debilitating problem .Thus may result in contraction stress and subsequent microleakage and adhesion failure. [1]

Many clinical techniques have been introduced to minimize the shrinkage stress and thereby reduce gap formation, such as control of the curing light intensity, [2] indirect placement of resin restorations, [2] application of a flowable resin liner, [3] and incremental layering techniques. [2]

However, no method has been shown to be totally effective in abating the effects of polymerization shrinkage. [4]

Incremental layering technique has been adopted as a placement technique, in order to combat polymerization shrinkage. But this technique has certain disadvantages such as difficulty in placement of increments in small cavities, increased operational time, interlayer contamination, incorporation of voids and difficulty in maintaining isolation. [5]

In order to reduce the time and effort needed for layering when placing posterior composites, a novel restorative approach was appeared based on the use of high-viscosity bulk-fill composites.

This technique can eliminate the possibility of voids between the layers enabling up to 4 mm increments to be cured in one step, without negatively affecting polymerization shrinkage kinetics and macro mechanical properties. [6]

The aim of this in vitro study is to compare and to analyze the sealing ability of High-viscosity bulk-fill composites in comparison to incremental posterior resin composite in posterior classII restorations with the dye penetration test.

2. Materials and Methods

2.1 Materials

In this study, two types of composite resin one indicated for bulk-fill (QuiXfil) and one composite for incremental-fill (Reflectys) were used. Names, codes, manufacturers, Types and compositions of the materials tested are summarized in Table 1.

Table 1: Materials used in the study

Material /Manufacturer	Lots / EXP	TYPE /Composition/ characteristics/Shade
QuiXfil (Dentsplay, Kostanz, Germany) (Bulk fill)	Lot : 0357 Exp : 2019-04	• Micro-hybrid • UDMA,TEGDMA,Di and Trimethacrylate • Charged at 85.5% (0.1-4;5-50µ) • Shade U
Reflectys (Itena)(incremental fill)	Lot : 617417 Exp : 2019-08	• Nano-hybrid • BisGMA, TEGDMA • Charged at 78.5 % rich in nanoparticles and microparticles, contains and releases radio-opaque fluorides at 220% Al Photopolymerizable • Shade E
Adper Single Bond 2 adhesiv (3M ESPE, St. Paul, MN, USA)	Lot : 6349096 Exp : 2019/04/30	Composition : • Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid copolymer, photoinitiators, water and ethanol
Master-Dent BLUE Etch Gel, 37% Phosphoric Acid (DentonicsInc (Master Dent))	Lot :MET1801291 Exp :2020/01/28	Composition : • Phosphoricacidat 37%

Bis-GMA: bisphenol A Glycidyldimethacrylate ;UDMA :urethane dimethacrylate; TEGDMA: trethyleneglycoldimeth acrylate. U:universal.

2.2 Methods

2.2.1 Sample selection

Thirty eight human maxillary and mandibularpermanent molars, with intact marginal ridge were collected for this experimentwith consent from the patients. All the crowns of the teeth were thoroughly cleaned with cleaning paste and a Prophy brush and rinsed with copious amounts of tap water before cavity preparation. Thus in order to remove tartar, soft tissues and other debris. (Figure1)

Figure 1: cleaning of the teeth before cavity preparation.

The teeth were then stored in physiological serumuntil the operating procedures.

All the teeth were examined under a stereo-microscope in order to verify that they are caries free, with no fluorosis or any structural alteration. Each tooth was numbered. (Figure2)

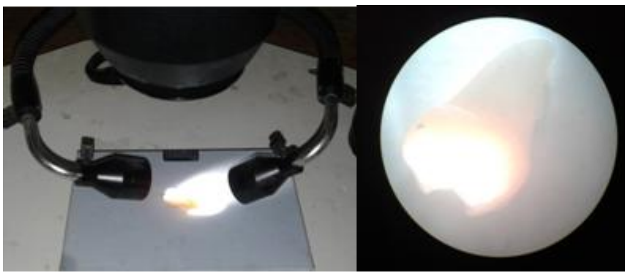

Figure 2: Examination of the teeth under a stereo-microscope.

2.2.2 Cavity preparation and filling

One standardized occlusal slot Class II cavity was prepared at the intact site of each tooth with standardized dimensions of 3.0 mm facio-lingually, 1.5 mesiodistally, and 3.0 mm occluso-gingivally,using tungsten carbide burs (#329 Maillefer, Ballaigues, Switzerland). It was then finished with fine diamonds (Busch, Engelskirchen, Germany) placed in an air-rotor handpiece driven by a parallelograph under constant water cooling. The cavity dimensions were verified by a digital caliper (accuracy ± 0.25 mm). The bur was replaced after every three preparations. (Figure 3)

Figure 3: Teeth after cavities preparation and finishing

The teeth were randomly divided into two experimental groups (n = 38). Each group was assigned to one of the materials tested. Shade selected for all materials was translucent. A clear Mylar Matrix Strip (Patterson Dental Supply, USA) was applied to the proximal surface and kept firm in place with a metal paper clip applied on the buccal and lingual surfaces of the specimen.

The cavities were totally etched with 37% phosphoric acid (3M ESPE) gel for 15s and were then thoroughly rinsed. The enamel margins were etched for an additional 15s before being thoroughly rinsed (10s) and gently dried for30s . Adper Single Bond 2 was applied with a micro-brush on all the surfaces (dentin, enamel) andthen light cured for 20s.

Group 1: The resin composite was applied in three increments of 2mm maximum. Each increment was light cured for 20s.

Light-cured materials were polymerized as per the manufacturer's instructions with a light-emitting diode (LED) curing emitting 800 mW/cm^2 in standard mode (EliparTrilight, 3M, ESPE) and 20s per 2.5mm layer.

Group 2: the resin composite was applied in one time and light cured using the same procedure.

At the end of the procedure,the composite resin fillings were Light cured for 40s with a light-curing unit in standard mode (800mW/cm^2) and Kept at 37 ° and 90% humidity for 24 hours(kcl solution).

They were then finished with superfine diamond burs (Busch, Engelskirchen, Germany) under continuous water spray and polished with medium and fine Sof-Lex™ discs (3M⁄ESPE) and silicone tips.(Figure 4)

Figure 4: cavities were filled with bulk fill resin in the mesial surfaces and with conventional composite resin in the distal surfaces

2.3 Thermocycling

The restored teeth were stored for 1 week in kcl solution 0, 6% at 37°C and then thermal-cycled in order to simulate the thermal variations observed in the oral cavity. The thermo-cycling technique proposed by Teplitsky et al. Was selected for this study.A daily cycles including 45 minutes at 4°C followed by 45 minutes at 60°C wererepeated four times. Thereafter, the teeth were kept for18 hours at room temperature. This daily cycle was repeated for five consecutive days allowing a total of 15 hours exposure at each extreme temperature.(Figure 5)

Figure 5: the restored teeth were stored in kcl solution 0.6% and thermal-cycled 45 minutes at 6°C followed by 45 minutes at 60°C

The entire surface of each specimen was then covered with two coats of varnish up to a 1 mm area from the restoration margins and the teeth roots were placed in transparent orthodontic resin. (Figure 6)

Figure 6: the teeth roots were covered with two coats of varnish up to a 1 mm area from the restoration margins and then placed in transparent orthodontic resin

2.4 Methylene blue infiltration

The teeth were soaked in 1% neutralized Blue Methylene solution (pH: 7.4) for 24 h at 37°C with their apices directed upwards. (Figure 7)

Figure 7 : teeth were immersed in Blue Methylene solution wih their apices directed upwards.

After the immersion period, the teeth were rinsed with water and cleaned with abrasive discs.

2.5 Teeth sectioning

The teeth roots were tagged and placed in transparent orthodontic resin cubes up to 1 mm from the cervical margin of the restoration in order to facilitate the grasping and sectioning of the crowns.

The crowns were removed from the roots using a diamond bur attached to a high-speed hand piece, embedded in epoxy resin, and longitudinally sectioned in a microtome (Buehler IsoMet) in a mesiodistal direction under continuous cooling into three slabs of 1 mm thickness. (Figure 8)

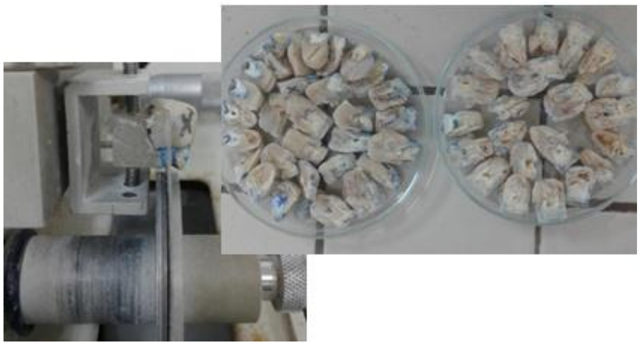

Figure 8: Sectioning of the teeth with a microtome (Buehler IsoMet) in a mesiodistal direction.

Sections were polished with a sequence of silicon carbide papers (320, 400, 800, and 1000), followed by felt impregnated with 1 and 0.25 µm grit diamond slurry used in an automatic polishing machine. Between each granulation and at the end, the specimens were cleaned and immersed in water in an ultrasonic bath.(Figure 9)

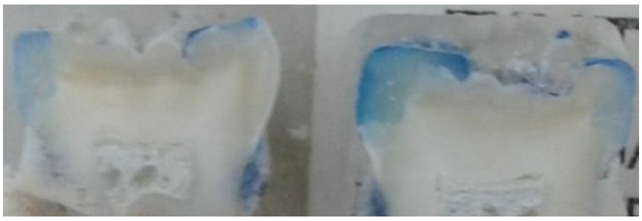

Figure 9: Crowns removed from the roots were polished

2.6 Observation under stereomicroscope

Adaptation to the enamel walls and dye penetration were assessed under a stereomicroscope (the Carl Zeiss™ STEMI 2000C ZOOM 6, 5 Stereomicroscope).

The score criteria were:
Score 0: perfect adaptation/no dye penetration;
Score 1: gaps and microleakage up in enamel not exceeding to dentin walls depth from the margins toward the axial wall;
Score 2: dye penetration exceeding to dentinalwalls of the gingival wall without reaching the axial wall;
Score 3: dye penetration reaching the axial wall.

2.7. Statistical Analysis

Statistics were done with SPSS20.0 software .The Khi-square test was used to study the scores distribution by level according to the composite resin used .The result was considered significant at p<0.05. Microsoft Office Excel 2010 software was also used to establish some numeric functions.

3. Results

3.1 Description

In this study, the infiltration scores of bulk-fill composite resin and incremental posterior resin composite were evaluated. Scores of infiltration of the two materials tested are calculated by cavities and not by half. For each product, we evaluated the infiltration present at the different cavities. The results obtained were counted according to the different scores observed and subsequently quantified in percentages (table 2).

Table 2: Table showing the distribution in percentages of infiltration scores between the two groups

	Score 0	Score 1	Score 2	Score 3	Total
Bulk Fill	65.78%	18.42%	6.57%	9.21%	100%
Relectys resin	47.36%	23.68%	10.52%	18.42%	100%

3.2 Results analysis

The dye penetration scores indicated that bulk fill resin (QuiXfil) showed significantly higher values when compared with Relectys composite resin (Itena) used with incremental technique (P < 0.001). It was observed that bulk fill composite resin had the least microleakage scores, whereas Reflectys scored slightly higher.

Bulk-fill composite resin showed the best results with the mean microleakage score value of <1, whereas Relectys composite resin showed a mean score value of more than 2. (Table 3)

Table 3: Statistical results comparing the distribution ofinfiltration scores between the two groups

SCORES	0	1	2	3		P value
Bulk fill	50(65.78 %)	14 (18.42 %)	5 (6.57 %)	7 (9.21 %)	76	
Incremental technique	36 (47.36%)	18 (23.68 %)	8 (10.52 %)	14 (18.42 %)	76	
	86	32	13	21	152	0.022073

*P < 0.05 Chi square test (comparing were made between score=0 VERSUS score≥1)
Chi-square score=5.24 › 3.84 ddl=1

The P-Value is 0.022073.The result is significant at p < 0.05.

4. Discussion

The aim of this study was to investigate and compare the sealing ability of bulk-fill resin composite and conventional resin composite. The bulk-fill composite showed lower infiltration values than conventional composite. The null hypothesis was rejected.

The limitations of the current study deal with the fact that not all commercial bulk-fill materials were included. With a greater sample size, more statistical discrimination among the main test factors of placement method, marginal interface location, and product could have been identified. However, it is felt that the product selection and sample size provide a very good initial overview of this new composite classification and placement technique.

The evaluation of the sealing ability of bulk fill composites in comparison with conventional incremental posterior composites to the dental interfaces require to focus on the factors in wish depend this property such as: the internal marginal adaptation and microleakage , shear bond strength , depth of cure , degree of conversion, shrinkage stress and the elastic modulus assessment of thus composites.

Various authors have evaluated the chemical and mechanical properties of bulk-fill composites. Some authors found lower mechanical properties than incremental posterior composites, others have stated otherwise.[7]

Alan Furness et al [8] examined the effects of composite type (bulk-fill/conventional) and placement on internal marginal adaptation of classII preparations. The found the marginal integrity was unaffected by placement method.no significant differences in gap-free margins were found between placement methods within a given product percolation. Except for SDR, percentage of gap-free margins was significantly lower at the pulpal floor interface than at the enamel interface for bulk-fill.

However, the curing lights used in this in vitro study were specific for each material and the degree of cure and subsequent marginal gap formation may have been influenced by this selection. Further studies are needed to elucidate the relationship between the curing light type and degree of cure.it is also recognized that each bonding agent used, although specific of each material, may have influenced the marginal gap and this relationship between the bonding agent and the bulk-fill composite needs to be studied further.

Neha Kapooor et al compared newer bulk-fill composites with incrementally filled composite for adaptability and subsequent gap formation at the pulpal floor. They concluded that bulk-fill composites provided better results than the incrementally filled conventional composites. The data collection of this study suggest that flowable bulk fill resin(SDR)showed the best adaptive capacity and the least gap formation as compared to other bulk-fll composites used because of its self-leveling property allowing optimal adaptation to the cavity walls. [9]

Hakan et al [10] Compared under in vitro conditions, shear-bond strength (SBS) of bulk fill and conventional posterior composite resins. They found that Bulk-Fill resin composites exhibited similar SBS values as the other conventional resin composites.

Bulk-fill composites differ most from conventional composites in their increased depth of cure, which could mainly be attributed to an increase in translucency. However, the literature is inconsistent regarding the determination of the depth of cure. [11]

According to the data collected in the study of Benneti et al [12] Bulk-Fill systems exhibited a higher depth of cure than the conventional resin composite.

Furthermore, a higher depth of cure has been previously reported for bulk-fill resin composites, and the differences between the two materials have been attributed to improvements in their initiator system and increased translucency. [13, 14]

According to a review of the current literature (Van Ende A et al) tests related to shrinkage stress induced by bulk-filling seem inconsistent and their clinical revelance is unclear. [11]

Fabio AntonioPiola Rizzante et al evaluated the polymerization shrinkage stress of nine different bulk-fill resin composites and their elastistic modulus .They found that Bulk fill resin composites presented equal to lower shrinkage stress generation when compared to conventional composites, especially when bigger increments were evaluated. Bulk fill composites showed a wide range of elastic modulus values, but usually similar to conventional incremental composites. According to the author volumetric shrinkage seems to be more important than the elastic modulus for polymerization stress development. [15]

In addition to these polymerization stresses alleviating strategies, bulk -fill manufactures claim that the filler and matrix translucency was increased and that the photo-initiator efficiency was optimized in order to ensure the degree of conversion. [16]

Different results were reported in literature regarding the degree of conversion of Bulk fill composites.

Y.A.Abed et al evaluated the degree of conversion and Vickers hardness of two bulk-fill composites (QuiXfil and X-tra fil) and one incremental-fill composite (Grandio).They conclude that X-trafil showed the most degree of conversion performance.However,Incremental-fill composite showed the highest Vickers hardness number than bulk-fill composites. No significant correlation was detected between degree of conversion and surface hardness and all materials had sufficient Vickers hardness results. Differences in degree of conversion and Vickers hardness number values among materials proved to be a material dependent. [17]

Diverse results were also reported regarding the microleakage.

A.Nour A et al investigated the degree of conversion and microleakage of bulk fill composites placed using different restorative techniques. They found that conventional incrementally- placed composite has a higher degree of conversion compared to all bulk fill types regardless of the technique used for the bulk fill composite. The sonic activated composite exhibits lower degree of conversion of the bottom composite surface than all other bulk-fill composites. Regarding the microleakage, bulk fill composites, used with any of their possible techniques, do not perform any inferior compared to incremental composites. [18]

Until now, no conclusive evidence is available to support or negate the effectiveness of bulk fill composites. In our study, the bulk filled composite used demonstrated betters' results than the incremental composites. According to these results cited it could be claimed that bulk fill composites demonstrated flow ability leading to good adaptation: elasticity and low polymerization shrinkage stress which reduces microleakage, reduced postoperative sensitivity and secondary caries; improved depth of cure of at least 4mm eliminating the need for layering[19],and can be cured in bulk as they are highly translucent which in turn allow the curing light to sufficiently penetrate to the bottom of single increment layer. [20]

However, more clinical studies that specifically focus on bulk-filling deep and large restorations are definitely required to fully explore the clinical benefits of bulk-fill composites. [11]

5. Conclusion

Although this study has a number of limitations; the results do that the application of bulk-fill composite results in acceptable sealing ability that is comparable to that achieved via conventional resin composites. As such, bulk-fill composites may represent reliable alternatives to conventional composites. This could be of potential benefit to dental technicians because bulk-fill composites are simpler than conventional composites and can be applied mere efficiently.

However, further studies are required in this area to better understand how the bond strengths of these adhesive systems behave under clinically acceptable conditions.

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References

[1] **Loguercio AD, Reis A, Schroeder M, Balducci I, Versluis A, Ballester RY, et al.** Polymerization shrinkage: Effects of boundary conditions and filling technique of resin composite restorations. J Dent. 2004; 32:459–70.
[2] **Lee MR, Cho BH, Son HH, Um CM, Lee IB.** Influence of cavity dimension and restoration methods on the cusp deflection of premolars in composite restoration. Dent Mater 2007;23(3):288-95
[3] **Alomari QD, Reinhardt JW, Boyer DB.** Effect of liners on cusp deflection and gap formation in composite restorations. Oper Dent 2001; 26(4):406-11.
[4] **Park J, Chang J, Ferracane J, Lee IB.** How composite should be layered to reduce shrinkage stress: incremental or bulk filling? Dent Mater 2008;24(11):1501-05.
[5] **Sesemann MR.** Placing a bulk fill composite to achieve predictable and esthetic posterior restorations. Oral Health J. 2012:43–8.
[6] **Ahmad I.** Deep resins,white fillings: A new technique for composite restorations. J Cosmet Dent. 2013; 3:22–31Rejaie,A.Al-Harbi,F.Kunzelmann.K.2016Degradation potential of bulk.
[7] **El Gezawi, M.Kaisarly.D,AlSaleh ,H.ArRejaie.A.Al –Harbi.F.Kunzelmann ,K.2016.**Degradation potential of bulk versus incrementally applied and indirect composites :color,microhardness, and surface deterioration.Oper.Dent.41,195-208.
[8] **Alan Furness, Marko YousefTardos, Stephen W.Looney, FrederickA.Rueggeberg.** Effect of bulk/incremental fill on internal gap formation of bulk-fill composites.Journal of Dentistry 42(2014) 439-449.
[9] **NehaKapoor,NikhilBahuguna,andSurbhiAnand**. Influence of composite insertion technique on gap formation.JConserv Dent.2016 Jan-Feb; 19(1):77-81.
[10] **hakancolak, ertugrulercan and Mehmet hamidi**. Shear bond strength of bulk –fill and nano- restorative mateials to dentin .Eur J Dent.2016 Jan-Mar;10(1):40-45)
[11] **Van EndeA,DeMunch J,LiseDP,VanMeerbeekB**.Bulk –fill composites :A Review of the Current Litterature. J Adhes Dent.2017; 19(2):95-109
[12] **BennetiAR,Harndrup-Pedersen C, Honoré D, Pedersen MK, PallesenU.**Bulk-fill resin composites: Polymerization contraction, depth of cure, and gap formation. Oper Dent .2015;40:190-200.[PubMed: 25216940]
[13] **Flury S, Hayoz S, peutzfelt A, Husler J, LussiA**.Depth of cure of resin composites: Is the ISO 4049 method suitable for bulk fill materials? Dent Mater.2012;28:521-8.[PubMed:22391146]
[14] **Lassila LV, Nagas E, Vallitu PK, GaroushiS**.Translucency of flowable bulk-filling composites of various thicknesses.Chin J Dent Rest.2012;15:31-5.[PubMed:22866280]
[15] **Fabio Antonio RIZZANTE ,Rafael Francisco Lia MONDELLI , Adilson Yoshio FURUSE , Ana FlaviaSanches BORGES , Gustavo MENDONCA, Sérgio Kiyoshi ISHIKIRIAMA** . Shrinkage stress and elastic modulus assessment of bulk-fill composites.J App Oral Sci .2019; 27:e20180132.
[16] **ChestermanJ,JowettA,GallacherA,NixonP**.Bulk-fill resin-based composite restorative materials:a review.Br Dent J 2017;222(5):337-44.
[17] **Y.AAbed, H.A.Sabry,N.A.Alrobeigy.Degree** of conversion and surface hardness of bulk-fill composite versus incremental-fill composite.Tanta Dental Journal 12 (2015) 71-80.
[18] **A.NourA .Habib,GihanH.Waly**.The degree of conversion and class II cavity microleakage of different bulk fill composites placed with different restorative techniques.Future Dental Journal 4 (2018)231-238.
[19] **SesemannMR**.Placing a Bulk Fill Composite to achieve Predictable and Esthetic Posterior Restorations.Oral Health Journal.2012.pp;43-8.
[20] **Ahmad I**.Deepresins,whitefillings:Anew technique for composite restorations.JCosmet Dent.2013;3:22-31.