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Composite Resin Bulk fill: Literature Review

Helena Pfeffer, Larissa de Oliveira Garcia, Marcio José Mendonça[2], Veridiana Camilotti[2], Paula Bernardon

University Street, 2069 – College, Cascavel-PR, Brazil, CEP 85.819-110
University Street, 2069 – College, Cascavel-PR, Brazil, CEP 85.819-110
University Street, 2069 – College, Cascavel-PR, Brazil, CEP 85.819-110
University Street, 2069 – College, Cascavel-PR, Brazil, CEP 85.819-110
University Street, 2069 – College, Cascavel-PR, Brazil, CEP 85.819-110
Corresponding Author: Helena Pfeffer

ABSTRACT

Composite resins have been widely used in clinical practice, however due to their incremental technique, up to 2mm, the clinical time is longer depending on the size of the cavity. In addition, composite resins upon polymerization have polymerization shrinkage, which can lead to breakage of the adhesive interface of the restoration, causing microleakage with consequent secondary caries, marginal staining and tooth sensitivity. To improve clinical performance Bulk-fill composite resins have been developed. The great technological innovation was the possibility of using unique increments (4-5mm) in order to optimize the professional's clinical time. This was possible due to changes in their composition, both in organic and inorganic matrix. It comes in viscosity compatible with the oral environment. and low viscosity, fluid resins used as restorations, requiring a conventional resin layer. Thus, this study aims to review the literature on recent researches with Bulk-fill resin compared to conventional resin and analyze its mechanical properties and advantages of its use. Thus, according to the established inclusion and exclusion criteria, 20 studies were selected from the PubMed database, in which they should make a comparison between Bulk Fill and conventional resin and be from 2012 to 2019 and then selected for the study. Concluding with this review that Bulk Fill resins have shown good results and clinical time optimization, however there are still controversies in their studies when compared to conventional composite resin.

KEYWORDS: *Composite resins;Dental restoration; Polymerization.*

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I. INTRODUCTION

Composite resins are increasingly being used by dental surgeons because of their ability to return function, anatomy and aesthetics to anterior and posterior teeth[1]. These materials are suitable for direct restorations, fragment bonding, bracket bonding, aesthetic and fractured tooth restorations. However, they are not indicated when the patient has a high caries index, inadequate oral hygiene, when it is not possible to control the humidity of the oral environment and lack of enamel in the cervical region of the dental preparation[2].

The main failures caused in composite resin restorations are secondary caries, restoration fracture, staining and microleakage[3]. And these failures are related to the properties of the composite resin used, adhesive system, polymerization shrinkage, and errors during the restorative technique[4]. In their composition, composite resins have organic matrix (monomers, initiators, color modifiers, inhibitors), inorganic matrix (filler) and bonding agent[3].

Monomers are the main components present in the organic matrix of composite resins, they have as function the union forming a “mass” in the lost tooth structure. Among the most commonly used monomers are Bis-GMA, UDMA, Bis-EMA, which are high molecular weight and TEGDMA, EGDMA, which are low molecular weight. Characteristics such as high molecular weight decrease polymerization shrinkage, however provide a low degree of conversion of the monomers at room temperature. In this way, low molecular weight diluent monomers are incorporated to reduce mass viscosity and improve material handling. Reactivity is the ability of the monomer to make bonds, the more reactive (higher degree of conversion) the greater the resulting polymerization contraction[3].

Conventional composite resins are widely used in clinical practice, presenting satisfactory aesthetic characteristics, however their incremental technique makes the clinical time longer. To this end, bulk-fill resins have emerged to reduce clinical time and improve the mechanical properties of the material[5]. A major disadvantage of resins is polymerization shrinkage, leading to breakage of the restoration interface, allowing fluid and bacteria to penetrate in the region and lead to tooth sensitivity, pulp irritation or even secondary caries[6]. Bulk-fill resins have some characteristics such as greater polymerization depth and lower polymerization shrinkage due to changes in their resin matrix, making the material more translucent so that the polymerization depth is increased and can be used in single increment, in addition to reducing its polymerization contraction[7].

From this, this literature review aims to evaluate the properties of bulk fill resins compared to conventional ones, showing whether or not there are greater advantages in their use, exploring their mechanical properties.

II. METHODOLOGY

The search for articles to perform the literature review was performed in the PubMed database on bulk-fill resins, searching for the terms "bulk-fill AND conventional" in which 213 articles were found. Inclusion criteria were articles that compared conventional composite resin and bulk fill, were published from 2012 to 2019 and evaluated the degree of conversion, polymerization shrinkage, microhardness, microleakage or marginal adaptation. in vitro and in vivo. The exclusion criterion was articles that did not compare bulk fill and conventional resins, articles that were not from the English literature and were not published in the requested period. Thus, 20 studies were selected to be exposed in this review, as well as other articles and books that supported the theme (Table 1).

1) **Table 1-** Studies selected for literature review

Author	Year of publication	Article title	Kind of study
Alshaafiet al.	2016	Effect of a broad-spectrum LED curing light on the Knoopmicrohardness of four posterior resin based composites at 2, 4 and 6-mm depths	In vitro
Benetti et al.	2015	Bulk-fill resin composites: polymerization contraction, depth of cure, and gap formation	In vitro
Czaschet al.	2013	In vitro comparison of mechanical properties and degree of cure of bulk fill composites	In vitro
Demirelet al.	2019	Volumetric Cuspal Deflection of Premolars Restored With Different Paste-like Bulk-fill Resin Composites Evaluated by Microcomputed Tomography	In vitro
Dijken J. W. V., Ulla P.	2015	Randomized 3-year Clinical Evaluation of Class I and II Posterior Resin Restorations Placed with a Bulk-fill Resin Composite and a One-step Self-etching Adhesive	In vivo
Dijken J. W. V., Ulla P.	2016	Posterior bulk-filled resin composite restorations. A 5-year randomized controlled clinical study	In vivo
Eweis, A. H.; Yap, A. U.; Yahya, N. A.	2019	Comparison of Flexural Properties of Bulk-fill Restorative/Flowable Composites and Their Conventional Counterparts	In vitro
Fronzaet al.	2015	Monomer conversion, microhardness, internal marginal adaptation, and shrinkage stress of bulk-fill resin composites	In vitro
Garcíaet al.	2019	In vitro evaluation of microleakage in Class II composite restorations: High-viscosity bulk-fill vs conventional composites.	In vitro
Garoushiet al.	2015	The effect of short fiber composite base on microleakage and load-bearing capacity of posterior restorations	In vitro
Gonçalveset al.	2018	.A comparative study of bulk-fill composites: degree of conversion, post-gel shrinkage and cytotoxicity.	In vitro
Junioret al.	2017	Is there correlation between polymerization shrinkage, gap formation, and void in bulk fill composites?	In vitro
Kim et al.	2016	Influence of the compliance and layeringmethod on the wall deflection of simulated cavities in bulk-fill composite restoration	In vitro
Lipikaet al.	2018	Influence of Light Energy Density, Composite Type, Composite Thickness, and Postcuring Phase on Degree of Conversion of Bulk‑fill Composites	In vitro
Loguercioet al.	2019	Randomized 36-month follow-up of posterior bulk-filled resin composite restorations	In vivo
Misilli T., Gonulol N.	2017	Water sorption and solubility of bulk-fill composites polymerized with a third generation LED LCU	In vitro
Nitta et al.	2017	Characteristics of low polymerization shrinkage flowable resin composites in newly-developed cavity base materials for bulk filling technique	In vitro
Rizzanteet al.	2019	Polymerization shrinkage, microhardness and depth of cure of bulk fill resin Composites	In vitro

Thongbai-On, Nathamonet al.	2019	Fracture resistance, gap and void formation in root-filled mandibular molars restored with bulk-fill resin composites and glass-ionomer cement base	In vitro
Yu, P.; Yap, A. U. J.; Wang, X. Y.	2017	Degree of conversion and polymerization shrinkage of bulk-fill resin-based composites.	In vitro

III. LITERATURE REVIEW

The mechanical properties of composite resins are of great importance for effective clinical performance of the material. Thus, the composite resins have organic matrix, filler particles and bonding agent[3]. Conventional resinous compounds are widely used in clinical dental practice, with satisfactory mechanical properties and good aesthetics. However, the disadvantage is the insertion of increments, leading to a clinical time, besides having a large polymerization contraction leading to marginal infiltration in the restoration[4].

For this, Bulk Fill composite resins are being widely used, and are divided into two categories, high viscosity that can be exposed to the oral environment and have mechanical properties compatible with conventional, and low viscosity, used as a basis because they can not be exposed to the buccal cavity due to its low mechanical properties. Thus,the 2 mm increment technique used in conventional resin is replaced by a mass increment, placed from 4 to 5 mm[8].

3.1 Polymerization Depth

The greater polymerization depth of Bulk Fill composite resin, when compared to conventional composite resin, is due to changes in the composition of this material. This may occur due to substitutions or changes in the charge particles, increasing translucency for this deeper polymerization[7]. Each material has its own system, as shown in table 2.

Table 2- Classification, composition and increment thickness of bulk fill resins

Trademark (Manufacturer)	Consistency rating	Maximum increment thickness	Conventional resin cover	Composition
Surefil SDR flow+Dentsplay	Fluid	4 mm	Yes	Barium glass aluminum boron fluorine silicate; Strontium glass aluminum fluorine silicate; Modified urethane dimethacrylate resin; Bisphenol Adimethacrylate ethoxylate (EBPADMA); triethylene glycol dimethyl acrylate (TEGDMA); Camphorquinone (CQ) as photoinitiator; Photo accelerator; Hydroxy toluene butylate (BHT); UV stabilizer; Titanium dioxide; Fluorescent Agents. Particle Size Inorganic compounds vary from 20nm to 10μm, with a load content by volume of 47.3%.
Filtek Bulk Fill Flow 3M	Fluid	4 mm	Yes	Treated silanized ceramics; Diurethanedimethacrylate (UDMA); Substituted dimethacrylate; Bisphenol A polyethylene glycol diethymimethacrylate (BISEMA); ITERBIO FLUORIDE; Bisphenol A diglycidyl ether dimethacrylate (BisGMA); Benzothriazole; Triethylene Glycol Dimethacrylate (TEGDMA); ETHYL 4-DIMETHYLAMINOBENZOATE.
X-tra base (VOCO)	Fluid	4 mm	yes	Silicon Oxide is the base substance in both inorganic fillers (nanoparticles and glass ceramic particles) - and in the resin matrix. The ceramic base in ORMOCER® (organically modified ceramic) technology consists of large, pre-condensed molecules of an inorganic matrix with a high degree of network bonding. 72% inorganic content.
Opus Bulk Fill flow (FGM)	Fluid	4 mm	Yes	Active Ingredients: Urethanedimethacrylic monomers, stabilizers, camphorquinone and co-initiator. Inactive Ingredients: Inorganic charges of silanized silicon dioxide (silica), stabilizers and pigments.
FiltekOneResina Bulk Fill (3M)	Regular consistency	5 mm	No	Inorganic filler particles are a combination of non-agglomerated / non-aggregated 20 nm silica particles, non-agglomerated / non-aggregated 4 to 11 nm zirconia particles, zirconia / silica nanoclusters (composed of 20 nm silica particles and (4 to 11 nm) and ytterbium trifluoride particles into 100 nm agglomerated particles. The inorganic content is about 76.5% by weight (58.5% by volume). AFM (monomer for dynamic

				relief of polymerization shrinkage stresses), AUDMA, UDMA and 1,12-dodecane-DMA.
Admira Fusionx-tra (VOCO)	Regular consistency	4 mm	No	Silicon Oxide is the base substance in both inorganic fillers (nanoparticles and glass ceramic particles) - and in the resin matrix. Does not contain classic monomers such as BisGMA, TEGDMA or HEMA. It is based on ORMOCER® technology (organically modified ceramic)they consist of large pre-condensed molecules of an inorganic matrix with a high degree of network bonds. 84% inorganic content.
Tetric N-Ceram Bulk Fill (IvoclarVivadent)	Regular consistency	4 mm	No	Photoinitiator Ivocerin, camphorquinone and 2,4,6-trimethylbenzyldiphenyloxide phosphine (acylphosphine oxide - comparable to Lucirin® TPO). Dimethacrylates: Bis-GMA, Bis-EMA and UDMA. Tetric N-Ceram Bulk Fill's organic matrix represents approximately 21% of the mass. It is the result of an optimized coordinated mix of monomeric matrix and fillers.
SonicFill (Kerr)	Regular consistency	4 mm	No	BisGMA; TEGDM; EBPADMA; EBPADMA; EDMA, SR-541; UV-9; CQ; UVTex-OB; EDMAB; HEMA-CL5-P; BYK-405; Colloidal silica; Fumed silica; Treated patrol; ZirkonSil infusion; YbF3; Pigments.
Aura Bulk Fill (SDI)	Regular consistency	4 mm	No	UDMA; BisGMA; BisEMA; TEGDMA.

In the in vitro study Rizzante et al. (2019)[8], was evaluated the polymerization depth of mass-filled composite resins with conventional (Admira XtraFusion, Filtek Bulk Fill, Tetric Evo Ceram Bulk Fill, X-traFil, Filtek Z350XT, Filtek Bulk FillFlowable, Surefil SDR flow, X-tra Base, Filtek Z350 flow). It was observed that all Bulk resins had a polymerization depth greater than 4.5 mm and that Filtek Z350 flow and Filtek Z350XT resins had a lower polymerization depth among the evaluated resins[8].

Benetti et al. (2015)[9] evaluated the polymerization depth of composite resins, for this purpose, high viscosity Bulk Fill resins (Tetric EvoCeram Bulk Fill, SonicFill) and low viscosity (X-tra base, Venus Bulk Fill, SDR) were compared with conventional resin (TetricEvoCeram). In this study, the high viscosity resins had a lower polymerization depth than that established by the manufacturers, and the SDR resin had the highest polymerization depth compared to the others used in this study[9].

While a systematic review by Reis et al. (2017)[10] searched in all literature in vitro studies that evaluated the polymerization depth of bulk fill composites and found that the low viscosity ones present better performance in relation to the polymerization efficiency when compared with the high viscosity ones[10].

3.2 Polymerization Contraction

Composite resins have monomers that, when polymerized, establish bonds that generate a polymerization shrinkage, that is, a reduction in the volume of the composite resin, and the larger the volume in the cavity, the greater the intensity, this is a factor that cannot be avoided. However, it can be modulated. The greater the polymerization shrinkage the greater the chance of damage to the bonding interface such as marginal infiltration, postoperative sensitivity and staining which decreases the life of resins in the oral cavity[11].Some factors may influence this contraction, such as the degree of conversion, the more monomers bond, the greater the polymerization contraction[8]. Material composition, the monomers present in the organic matrix of composite resins determine the reactivity and speed of the polymerization reaction[8]. The modulus of elasticity also influences the polymerization shrinkage, the higher the modulus of elasticity the greater the stresses during polymerization, which may lead to breakage of the adhesive interface[3].

Incremental technique for conventional composite resins is still recommended for proper conversion of all monomers, reducing the relative C factor (interface surface area ratio) at each increment to reduce the stress that leads to contraction[12] and increases wall adaptation cavity, which can cause enamel cracking and cusp deflection[13]. Kim et al. (2016)[13] evaluated the deflection of conventional resins compared to photoactivated Bulk Fill without aluminum molds of various thicknesses, and the results showed that the single increment technique resulted in greater restoration wall deflection[13]. A factor to be questioned, because in a recent study, Bulk Fill resins had a lower cusp deflection than conventional resins[14]. However, the difference of these studies may have occurred due to different methodologies and even resinous compounds of different compositions used in each study.

The polymerization shrinkage of Bulk Fill composite resin compared to conventional resin is reported and contradictory in the literature. It was observed that the high viscosity Bulk-Fill composite resins had polymerization shrinkage similar to the conventional ones, while the low viscosity resins had higher polymerization shrinkage compared to the conventional ones[9]. Other studies have shown that both high and low viscosity Bulk-Fill composite resins had lower polymerization shrinkage than conventional resins[8,15]. Fronza et al. (2015)[5], demonstrated that Bulk-fillEverX Posterior composite resin presented higher polymerization contraction than the conventional one, and that only the high viscosity composite resin (Tetric Evo-Ceram Bulk-Fill) presented lower polymerization contraction than the conventional one[5]. Nitta et al. (2017)[16] evaluated the polymerization shrinkage according to ISO/FDIS 17304, where bulk fill composites (Bulk Base Medium, Bulk Base High flow and Filtek Bulk Fill) were compared with conventional resins (FiltekSupreme Ultra and In this study, bulk fill resins showed significantly lower polymerization shrinkage and higher polymerization depth compared to conventional ones[16].

Thus, in vitro evidence is still conflicting, more clinical studies are needed[12]. Two studies, however, seem to indicate that restorations placed with the bulk fill technique (4 mm) were not different from those placed with the incremental technique (2 mm). The two techniques were performed in the same patient, totaling 38 restorative pairs, in a 3-year follow-up17 and 5-year follow-up[18], that is, both techniques were effective.Loguercio et al. (2019)[19] in a randomized clinical trial compared the incremental technique with the Bulk-Fill technique in 236 cavities followed for 36 months, as a result, the bulk fill technique showed excellent clinical performance, comparable with the 2 mm incremental technique. Thus, attention should be focused on the correct photoactivation of Bulk Fill composite resins, which is at least 20 s to achieve conversion levels comparable to conventional incremental insertion composite resins[12].

The polymerization contraction during monomer bonding can lead to gap formation at the restoration interface, causing microleakage, in which fluids pass between the restoration and the tooth, and may also lead to secondary caries formation. Another important factor for posterior teeth restorations is the reproduction of an adequate contact point, since loose proximal contacts predispose food impaction, carious lesions and periodontal complications[21].

El-Shamy et al. (2017)[21] evaluated the contact point of conventional and Bulk Fill resins. The conclusion of this study was that Bulk-Fill composite resins (SonicFill and TetricEvoCeram) showed comparable contact point to conventional composite resins. The separation ring was the recommended method to obtain adequate contact point in Bulk Fill composite restorations[21].

3.3 Microinfiltration

Some recent studies have evaluated microleakage and gap formation between restoration and tooth (GAPs) in conventional Bulk fille resin restorations. García et al. (2019)[20], showed that all restorations presented microleakage, especially in the gingival walls that did not end in enamel, due to the decrease in restoration volume in the region and failure of adhesion of the composite resin with dentin and cementum[20]. In 2019, another study evaluated the formation of gaps with computed tomography, which found that bulk resins had gap formation similar to conventional resins[22]. Benetti et al. (2015)[9] found that high viscosity Bul-Fill composite resins had similar gap formation than conventional ones and that low viscosity resins had higher GAP formation. Fronza et al. (2015)[5] demonstrated that conventional resins had a lower GAP formation than fillers, suggesting the use of the incremental technique[5].

Junior et al. (2017)[23] evaluated the formation of GAPs by means of computed microtomography in conventional and bulk-fill composite resins, and their results observed that the high viscosity Bulk-Fill composite resins presented similar GAP formation to conventional resins, however, the performance of High viscosity was better when compared to low viscosity resins at marginal integrity[23].

Garoushi et al. (2015)[24] evaluated microleakage in class II restorations with conventional composite and Bulk-fill resins, by means of their results found that conventional Tetric N-Ceram resin and posterior Ever X resin had a lower percentage of microleakage compared with other resins[24]. Results in the literature indicate a great tendency to use Bulk Fill composite resins in posterior teeth restorations, especially in class II. Fluidity and application in larger increments improves material adaptation in the cervical third.

3.4 Degree of conversion

The degree of conversion of monomers is directly related to physics and mechanical properties such as strength, hardness, solubility, color changes, and biocompatibility of composite resin products, being affected by organic matrix chemistry, fill type, amount, size, light distribution, photoinitiator, time, mode and intensity of light curing[25]. The degree of conversion is the ability of monomers to bond and form chains, and the higher this degree of conversion, the greater the mechanical properties of the material, as more monomers turn into polymers, but the greater the polymerization contraction[3].

Some studies have evaluated the degree of conversion between bulk fill and conventional composite resin. Gonçalves et al. (2018)[26] evaluated the degree of conversion between conventional Bulk Fille resins using FTIR spectroscopy, which found that only three of the Bulk Fill resins had similar conversion rates to conventional 4 mm thickness, which are Venus Bulk FillFlow, Filtek resins. Bulk Fill Posterior and Filtek Bulk Fill Flow[26].

Fronza et al. (2015) also assessed the degree of conversion of conventional and Bulk Fill resins by the spectroscopy method, analyzing that only Surefil SDR and Filtek Bulk-Fill resins had a similar conversion degree throughout the restoration[5]. Another study compared the degree of conversion measured before and after spectrometer polymerization between conventional and fill composite resins, this degree of conversion was measured at 2, 4 and 6 mm[15]. The results showed that at all depths Smart Dentin Replacement resin had a higher degree of conversion and Beautifil Flow Plus the smallest at 6 mm, whereas in conventional composite resins the depth of 2 mm had a higher degree of conversion compared to 4 and 6 mm[15].

Lipika et al. (2018) evaluated the effect of light energy density (11.2 J/cm2 and 20 J/cm2) on the degree of conversion and variation of the degree of conversion of monomers in immediate post-photoactivation and after 24 h in bulk resins fill with an FTIR spectrometer equipped with attenuated full reflectance fitting. In conclusion, energy density greater than 20 J/cm2 with longer photoactivation time (20 seconds) and low power density of the device helps to achieve high density bulk filler resin with better monomer conversion also on the lower surface[25].

Regarding solubility, directly related to the degree of conversion of monomers[25], Misillie and Gönülol (2017) photoactivated different composite resin and Bulk Fill specimens stored in distilled water for 30 days to evaluate water sorption and solubility according to ISO 4049: 2009 for samples. The conventional composite resin group had higher water absorption value than bulk fillers. The samples exposed to high power by the photoactivator showed higher water sorption. The reduction in polymerization time significantly increased SonicFill sorption, which showed the highest water solubility value among the composite resins tested[27].

3.5 Hardness

For composite resins to have good clinical performance they must have good mechanical properties and be wear resistant[28]. For this, studies have evaluated the hardness between Bulk Fill and conventional composite resins. Fronza et al. (2015), evaluated the microhardness by spectroscopy of Bulk Fill and conventional resins, demonstrating that the placement technique and depth of the resins did not interfere with microhardness, except Tetric Evo-Ceram Bulk-Fill which showed low values of microhardness at greater depths[5]. Rizzante et al. (2019) also evaluated microhardness, finding that low viscosity Bulk resins had lower microhardness compared to high viscosity, Filtek Z350XT was the one that presented higher microhardness[8]. A study by Thongbai-on et al. (2019), evaluated the hardness of conventional and Bulk-Fill resins. Among the results, Bulk-Fill resins were harder than their conventional and flow resins, except Filtek Bulk-Fill Flowable resin, which presented higher surface hardness than its conventional and Bulk-Fill. Recently a study evaluated the fracture resistance of filler and conventional resins using a universal testing machine and found that conventional and Bulk composite kerosines had similar fracture resistance[22].

Bulk Base Medium flow resins, Bulk Base High flow resins, Filtek Bulk Fill resins, FiltekSupreme Ultra, MI flow were evaluated for Knoop hardness with a hardness microtester (HMV-1, Shimadzu, Kyoto, Japan), bending strength with a test machine (AG-IS 20kN, Shimadzu) and the modulus of elasticity obtained by fracture load, deflection and elastic limit. Hardness, flexural strength and modulus of elasticity were lower than conventional composite resins[16].

Alshaafi et al. (2015) also measured Knoop microhardness with a testing machine (Bluephase 20i) with several resins, including Bulk. Bulk-Fill resin showed lower hardness than conventional resin (X-trafil and SoonicFill), but higher than SureFil SDR Flow. In Tetric Evolution Bulk Fill there were significant differences in knoop hardness values between the increment of this material with 2 and 4 mm, and the 2 mm showed higher hardness. Although alternative photoinitiators such as ivocerim, present in Bulk resin, are more reactive than camphorquinone, particle size and increased Rayleigh scattering, few of the shorter wavelength photons reach the bottom of the 6mm material thickness, therefore Bulk resin should be activated with a shorter wavelength[30]. It is noted that in these microhardness studies, some use Vickers others Knoop, so there is no standard for bulk resins, and there is no exact conclusion with the studies. Thus, some standardization would be interesting when investigating the polymerization characteristics of Bulk resins[30].

IV. CONCLUSION

Bulk Fill resins have shown good results regarding the ease and optimization of clinical time, however, there are still some controversies in the literature regarding their physical and mechanical properties compared to conventional resins. In general, composite filler resins have good properties that are warranted by manufacturers and have taken increasing space in clinical use. Thus, research needs to be focused on what is the best brand to use among the available Bulk Fill resins, choosing the one with the best physical and mechanical properties. It is important to perform proper restorative technique, proper increments according to the material and photoactivate with the proper power and time.

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