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Literature Review

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Microleakage of bulk fill polymer-based composite: review of the literature

Abstract

Currently, the most widely used dental restoration materials in the field of dental aesthetics are polymer-based composite; therefore, the offer within the market is increasing with a focus on aesthetic, mechanical, and process improvement needs. Bulk fill or block filling polymer-based composite has been widely accepted, they have an advantage because they can be placed in blocks of up to 4 to 5 mm[1] reducing clinical times in contrast to traditional polymer-based composite. Therefore, within the present study, we have focused on investigating the microleakage of this type of polymer-based composite and what are the main reasons for it.

Objectives: A literature review on the evaluation of the degree of microleakage of bulk fills polymer-based composites.

Methodology: An electronic literature search was performed on bibliographic bases such as PubMed, Scielo, Science Direct, Cochrane, and Wiley Online using the keywords: "marginal adaptation", "bulk fill resin", "bulk fill composite", and "microleakage".

Conclusions: Block filling polymer-based composite tends to have the same amount of microleakage as conventional polymer-based composite. Adhesive systems are essential to greatly reduce the formation of gaps between dental materials and dental structures. Class II cavities will always be better to treat the proximal face first and then manage as a class I to reduce marginal microleakage. The fluid block filling polymer-based composite used as a base greatly helps the adaptation of the polymer-based composite and decreases marginal microleakage.

Keywords: marginal adaptation, bulk fill resin, bulk fill composite, microleakage

Volume 13 Issue 4 - 2022

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Received: July 21, 2022 | **Published:** October 12, 2022

Introduction

Bulk fill polymer-based composite has special characteristics such as being a one-step restorative material, easy to use, and designed to simplify operating times in posterior sector restorations[2] that make it a tool innovative, where they present a high degree of efficiency, in this way it has become one of the most used materials with great reception and many professionals prefer it due to the optimization and simplification of processes in clinical periods, that is why these polymer-based composite have currently taken a place in the market as highly resistant and very useful materials for the application of restorations.[3] Among the disadvantages of these materials, we can mention marginal microleakage, which would become a setback and one of the main factors of failure in dental restorations today,[4] this can be caused due to polymerization shrinkage.[5,6] All polymer-based composites suffer from this phenomenon. However, bulk-filled polymer-based composites tend to have lower polymerization shrinkage due to their high translucency and lower inorganic filler.[7] There is no doubt that bulk fill-type materials save time, avoid the use of additional layers or even save the use of additional dispensing devices that can become expensive;[8] for this reason, the objective of this bibliographic review is to evaluate the degree of microleakage of composites based on massive filler polymers.

Methodology

Search strategy: a review of the literature was carried out to identify the articles that meet the requirements established in the inclusion and exclusion criteria, it was carried out through the Spanish and English literature of the last 5 years and in this way obtain information on the marginal microleakage of bulk fill type polymer-based composite.

An electronic literature search was performed on bibliographic bases such as PubMed, Scielo, Science Direct, Cochrane, and Wiley Online using the keywords: "marginal adaptation", "bulk fill resin", and "bulk fill composite" (Figure 1). The inclusion and exclusion criteria were applied to have the articles analyzed.

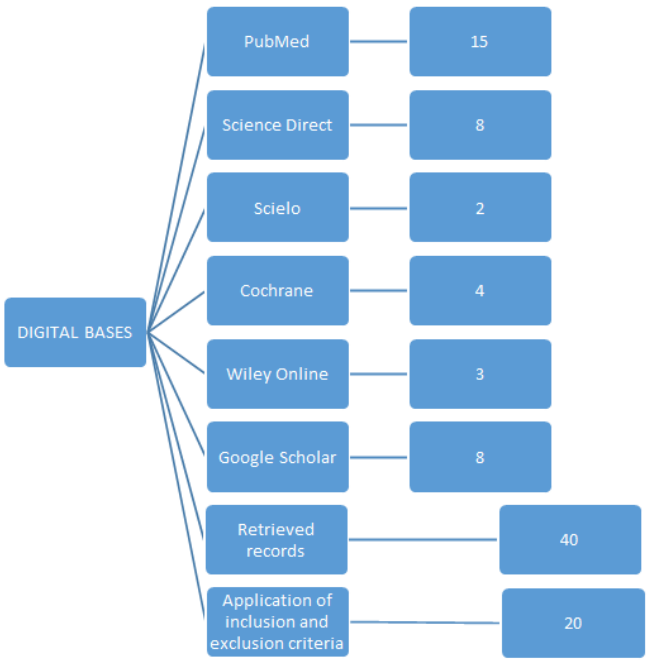

Figure 1 Electronic literature search.

Inclusion criteria:

- Scientific articles published in the last 5 years
- Articles published in English and Spanish
- Systematic reviews
- Clinical studies
- Studies carried out in permanent dentition

Exclusion criteria:

- Studies were conducted on patients under 16 years of age.

PubMed, n=15; Science Direct, n=8; Scielo, n=2; Cochrane, n=4; Wiley Online, n=3; Google Scholar, n=8

Results

In the study carried out by Jinez P. et al,[9] using 30 premolars, they were randomly restored into two groups. The first group was restored with Tetric EvoCeram® (Ivoclar) nano-hybrid polymer-based composite in 2-mm increments and the second group with bulk fill nano-hybrid polymer-based composite (Ivoclar) in 4-mm increments. Using a thermocycling technique for 5,000 cycles, they were subsequently immersed in methylene blue for 24 hours. Finally, a uniform sagittal cut was made and the depth of the marginal microleakage at the base of the proximal box was evaluated employing a stereo microscope, they have highlighted the notable decrease in the leakage in proximal boxes of class II cavities. So that it was observed that marginal leakage of these two types of polymer-based composite was similar, in turn, it is stated that bulk fill composite polymer-based composite reduces systematization time.[10]

On the other hand, Van Dijken y Pallesen,[11] in their study evaluated a flowable composite polymer-based composite bulk fill technique in posterior restorations and compared it with a conventional 2 mm polymer-based composite layering technique during a follow-up period 6 years old.[11] Thirty-eight pairs of Class II restorations and 15 pairs of class I restorations were placed in 38 adults. A one-step self-etch adhesive (Xeno V) was applied to all cavities. Flowable polymer-based composite (SDR) was placed in the first cavity of each pair, in bulky increments of up to 4 mm. The occlusal part was completed with a layer of nanohybrid polymer-based composite (Ceram X mono). In the second cavity of each pair, the hybrid polymer-based composite was placed in 2 mm increments. It was appreciated that the restoration technique, whether incremental or in the block, did not show a significant difference in terms of microleakage, finding that the block filling polymer-based composite improves operative times and decreases contamination of the cavity.[12]

In the study carried out by Jung JH y Parque SH,[4] it was observed that bulk-type or block-filling polymer-based composite decreased polymerization contraction using a good technique and improve marginal adaptation using a sandwich technique with glass ionomer, for the same used Filtek Z350 polymer-based composite (3M ESPE, St Paul, MN, USA) which was the regular incremental fill polymer-based composite compound, SDR (Dentsply Caulk, Milford, DE, USA) and Venus Bulk Fill (Heraeus Kulzer, Dormagen, Germany) were the flowable polymer-based composite, and Tetric N-Ceram Bulk Fill (Ivoclar Vivadent, Schaan, Liechtenstein) and SonicFill (Kerr, West Collins, Orange, CA, USA) were block-filling polymer-based composite. Using extracted human teeth with class II preparations, adhesive (XP Bond, Dentsply Caulk) was applied and light-cured on the occlusion, medial and distal sides with an LED light-curing unit (Bluephase N, Ivoclar Vivadent, 1140 mW/cm^2) for 20 seconds in each position. The same curing light was used in the following polymerization process for the polymer-based composite. It was noted that the bulk-filled polymer-based composite showed better marginal adaptation and lower polymerization shrinkage.[7]

Signore A. et al,[13] used two types of adhesives, the etch-and-rinse (ER) and self-etch (SE) adhesive systems. Among the dental materials used in this study were: Group 1: Futurabond U universal adhesive (FbU) (VOCO; Cuxhaven, Germany) in SE mode/Composite nanohybrid Bulk-fill Admira Fusion x-tra (AFx-tra) (VOCO; Cuxhaven, Germany) Group 2: FbU in ER/AFx-tra mode Group 3: FbU in SE mode/Admira Fusion (AF) nanohybrid composite (VOCO; Cuxhaven, Germany) Group 4: FbU in ER/AF mode. Observing that the type of filling technique and filling material had no statistically significant influence on the results; at the same time, statistically, significant differences were observed between the modes of application of the universal joint system. Thus, in this study applying the etch-and-rinse (ER), adhesive systems resulted in a significantly better marginal seal than the (SE) self-etch adhesive systems, regardless of the restorative material placed. The single increment, polymerization, and volume application method carried out in the present study did not negatively affect the marginal adaptation of the restorations.[14]

Marin B. et al,[15] investigated the adaptation of bulk polymer-based composite using three bulk fill restorative systems: Tetric EvoCeram Bulk Fill with Tetric N-Bond (TEC/TNB), SureFil SDR Flow with XP Bond (SDR/ XPB) and Filtek Bulk Fill Flowable Restorative with Scotchbond Universal (FBF/SBU); comparing it with a conventional restorative system: Herculite Classic with OptiBond FL (HER/OBF). Giving as result, the filtek bulk fill fluid restorative polymer-based composite provided a better marginal adaptation. The Opti Bond FL system is considered the "gold standard" bonding agent within etching and rinses bonding systems.[15] It has been suggested that the optimized hybrid layer formation in demineralized intertubular dentin and the filled adhesive polymer-based composite applied on the primed dentin surface contribute to enhanced physical properties. Both conventional and bulk fill type polymer-based composite have similar characteristics in terms of adaptation, as they age they lose bond strength in the same way.[16]

Loguercio A. et al,[11] in vivo study, they evaluated the 36-month clinical performance of the layering technique (incremental [IF] vs. bulk-fill [BF]) in self-etch bonded posterior polymer-based composite restorations (SE) and etch and rinse (ER) strategies. Restorations were bonded with Tetric N-Bond ER or Tetric N-Bond SE. Tetric N-Ceram Bulk-Fill polymer-based composite was placed IF or BF. Restorations placed with the block-fill technique showed similar performance to those placed with the traditional 2-mm incremental technique after 36 months of clinical evaluation. This makes bulk fill restoratives attractive for use in posterior tooth cavities when large, deep cavities are to be restored. Regarding marginal discrepancies, no significant differences were observed when incremental versus massive fill techniques were compared after 36 months of clinical evaluation. The results of the present study showed that the restorations with the best marginal adaptation and with the least marginal discoloration were those bonded with the etch-and-rinse adhesive. According to Heintze et al, the trend towards a higher risk of marginal discrepancies of restorations bonded with self-etch adhesives instead of etch-and-rinse adhesives is due to the lower enamel etching pattern of self-etch systems. The bulk-filled polymer-based composite evaluated in this study showed similar clinical performance when used in bulk or incrementally, as all restorations were rated 'clinically acceptable'. Regarding the adhesive strategy, the etch-and-rinse strategy showed less marginal discoloration and better marginal adaptation than the self-etch approach.[11]

In the research carried out by Putignano A. et al,[2] they compared three different restoration techniques, observing that the snow removal technique, which consists of 1) placing a thin layer of uncured fluid Bulk Fill composite as the lower lining of the cavity; 2) filling the rest of the cavity with a single increment of BFC compressible up to the occlusion surface, using high viscosity bulk composites and another low viscosity fluid, this improves adaptation to the cavity and decreases marginal microleakage.[2]

Another study Tosco V. et al,[15] used micro-computerized tomography (μ-CT) and scanning electron microscopy (SEM) together with energy dispersive X-ray spectroscopy, to assess the degree of microleakage.[3] Using eight extracted human third molars and with two preparations of proximal, distal and oclussal cavities, using two filling techniques: BG (Bulk & Go group) which consists of restoring the cavity in a single increment, and BT (Traditional Bulk Group) which restores the proximal wall first and then treats it as a class I cavity. Neither of the two techniques showed a significant difference, but the results of the present investigation can support that when the clinician is faced with a class II cavity, it would be useful to restore the proximal wall first, to transform the class II cavity into a class II cavity class I.[15]

Politi I. et al.,[17] quantified microleakage using the thermo cycling technique and stereoscopic microscopy in extracted human third molars, observing that the microleakage of bulk fill polymer-based composite was higher than conventional but decreased when modifying the protocol of restoration, generating class II cavities in class I.[18]

Akimasa T. et al.,[19] compared various types of new-generation flowable polymer-based composite with a flowable such as filtek bulk fill flowable (FF, 3M Oral Care, St. Paul, MN, USA). Using a total of 60 extracted human teeth, the presence, location, and extent of marginal spaces were determined using a mobile microscope. New generation flowable composites showed 57–79 μm for sum and 0.16–0.22% for marginal gap formation rate, similar results to conventional ones (50 μm and 0.14%) and bulk-fill (62 μm and 0.17%) compounds. There were no differences in marginal fit between materials and material types. It was found that the flexural properties and bond strength of enamel and dentin of flowable polymer-based composite and bulk fillers are much lower immediately after polymerization than after 24 h, regardless of the type of flowable polymer-based composite.[3]

The study carried out by Sampaio C. et al.,[1] quantifies the volumetric polymerization shrinkage (VPS) of different conventional and massive filler polymer-based composites, through computerized microtomography (-CT), and qualitative comparison of the formation of voids by optical coherence tomography (OCT), using in class I cavities, observing that the conventional polymer-based composite presented statistically higher VPS than the high-viscosity block filling materials studied, and most of the contraction of volumetric polymerization was observed in the upper part of the samples (occlusal) and part in the pulpal floor. Because the bulk fill polymer-based composite present a silan filler that acts as a contraction stress releaser and provides a lower elastic modulus, reducing the stress and, therefore, the interfacial gap; therefore, they decrease marginal leakage compared to conventional polymer-based composite.[1]

Peutzfeldt A. et al.,[20] using 39 human teeth extracted for 6 months and with the application of conventional polymer-based composite and fluid bulk fill, through aging by thermocy and mechanical brushing, it was observed that conventional polymer-based composite has a leakage similar to flowable bulk fills, microcomputer tomography showed that in enamel, the conventional polymer-based composite showed less void formation than "block fill" flowable polymer-based composite, before and after artificial aging. In dentin, on the other hand, the "bulk-filled" polymer-based composite showed less void formation. Whether marginal gaps form and the extent to which they form depends on interplay between multiple factors, some related to the polymer-based composite, others related to the specific cavity and restorative procedure.[20]

Habib N. y Gigan W.,[14] they investigated the degree of conversion and microleakage of bulk-fill composites, using different restorative techniques. Forty-five extracted caries-free human premolars were used for microleakage evaluation. One or two class II slot cavities, with standardized dimensions, were prepared in each tooth. They were subjected to thermo cycling where they were alternately immersed in water baths at 5 °C and 60 °C for 1000 cycles with a residence time of 30 s. The degree of conversion is a critical factor that greatly influences several properties related to the longevity of the composite restoration, such as solubility, color stability, mechanical properties, and even biocompatibility. It was appreciated that the block filling composites, regardless of the restorative techniques implemented, did not perform less efficiently compared to the incremental composite, indicating that microleakage is a multifactorial phenomenon that is not only influenced by the degree of conversion. Other factors may also play a role, such as the amount of polymerization shrinkage, the direction of polymerization stresses, as well as the flow properties of the uncured composite that affect its ability to achieve efficient wetting of the cavity walls. The restorative technique used with bulk-fill composites does not affect the potential for microleakage, which is comparable to that of incrementally placed composite.[21]

Discussion

In dental restorations, mechanical strength, good interfacial adhesion, and correct material coating are key factors in the longevity of restorations. Dentin hypersensitivity, dental caries, cement dissolution, plaque retention, and periodontal problems are consequences of poorly adjusted margins; therefore, more and more dental materials seek to improve marginal adaptation and reduce these failures.[4] It is well known that polymer-based composite requires a dry field, critical steps for etching, priming, and bonding of enamel and dentin, and the maximum incremental thickness has historically been 2 mm. Even so, restoring deeper preparations in 2-mm increments is time-consuming and relatively technique-sensitive. The rationale for the incremental fill technique is to ensure penetration of curing light deep enough to initiate and complete polymerization of polymer-based composite, in addition to minimizing associated shrinkage and shrinkage-induced stress with the polymerization of polymer-based composite compounds. However, recently, manufacturers have introduced massive filling composites such as bulk fill type polymer-based composite, and it has been claimed that they can fill cavities of up to 4-5 mm at a time. Several bulk fill composite materials are currently on the market, including low and high-viscosity formulations.[16] The type of bulk fill polymer-based composite has been applied in various techniques such as the monobloc technique, the horizontal, and oblique incremental techniques, the microleakage of the bulk polymer-based composite is the result of variables to consider that are within the following aspects:

- Use of adhesives
- Light curing lamps
- Technique[21]

The snow removal technique provides an excellent alternative since it allows for obtaining an adequate and optimal marginal seal

adaptation of the Bulk Fill composite material, especially in deep and difficult-to-access cavities. Marginal adaptation is one of the critical concerns in posterior composite restorations. The marginal sealing of these restorations involves several factors, such as the size and geometry of the cavity, the physical/mechanical properties of the polymer-based composite in the layering protocol by García Marí et al.,[9] and the lack of placement of restorative material in the cavity by Kwon et al.[10] The viscosity of the composite plays an important role in the marginal adaptation of the cavity walls, especially in areas of difficult accessibility by Boruziniat et al.[15] Therefore, an intermediate veneer application, using a flowable composite, has been recommended to minimize marginal leakage as well as gap formation in the restorations.[13]

Bulk fill polymer-based composite has a lower polymerization shrinkage compared to conventional polymer-based composite, so it is safe to make applications of 4 to 5 mm of polymer-based composite. Light-curing lamps do not greatly influence polymerization shrinkage, but it is recommended to use lamps of at least 1200 mW for 20 to 40 seconds for complete polymerization. The "snow plow" technique provides an excellent alternative since it allows obtaining an adequate marginal seal and optimal adaptation of the BFC material, especially in deep and difficult-to-access cavities.

When restorations are placed below the LAC, the quality of the marginal integrity is uncertain. It should be handled in a good way and give the appropriate morphology to the polymer-based composite while the restoration is being carried out and avoid shaping after finishing them, since the flexural properties and the bond strength of enamel and dentin are much lower immediately after polymerization than after 24 h, regardless of the type of polymer-based composite.[22]

Conclusion

Throughout this study, we were able to appreciate that block filling polymer-based composite tends to have the same amount of microleakage as conventional polymer-based composite. Etch-and-rinse adhesive systems provide a better marginal seal, regardless of the restorative material used. Class II cavities will always be better to treat the proximal face first and then manage as a class I to reduce marginal microleakage. The fluid block filling polymer-based composite used as a base greatly helps the adaptation of the polymer-based composite and decreases marginal microleakage.

Recommendation

In future research, it is recommended to carry out a thorough search of all the possible disadvantages of block filling polymer-based composite, thus be able to learn more about these polymer-based composite, and better manage these materials.

Acknowledgments

We thank the University of Cuenca for providing us with the tools to carry out this research.

Conflicts of interest

The author declares no conflicts of interest.

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Citation: Brito BPT, Guerrero VJR, Carrasco MFL. Microleakage of bulk fill polymer-based composite: review of the literature. *J Dent Health Oral Disord Ther.* 2022;13(4):77–81. DOI: 10.15406/jdhodt.2022.13.00577