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Effect of Microleakage in Composite Filling on the Health of Dental Pulp

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Abstract

Introduction: Clinical consequences of microleakage are secondary caries, pulp inflammation, marginal discoloration, postoperative sensitivity, and the reduction of longevity of filling. Dentists expect from modern technology a composite material with high aesthetic value, less polymerization shrinkage, perfect marginal integrity, and relevant physico-mechanical properties. This review aimed to investigate the problem of microleakage in composite filling, as well as the effect of microleakage on dental pulp.

Methods: An online search about relevant papers was conducted, which include PubMed indexed literature, was performed by combining the term "bulk fill" and “microleakage” using the AND operator, from time to time to the terms of class II, class III, and V to try to introduce the studies that referred to the design of the cavity. The search strategy, performed using the PubMed controlled vocabulary and free terms, was defined on the basis of the following elements of the PICO question: The eligibility criteria are: in vitro or in vivo studies, published in the last 20 years (given the date of introduction of the material on the market) and written in English. It was decided to include studies on human teeth and in vitro studies to have a standardization of the cavity, which would not be possible to obtain in an in vivo study.

Results: In comparison to conventional composite, 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. However, the dentine micro-leakage was higher than conventional at score 0, equal at score 1 and 3, lower than conventional at score 2. Regarding cavity preparation, using a less traumatic system such as laser systems may be favorable in pediatric dentistry. Hence, lasers can ablate enamel and dentin more effectively due to the highly efficient absorption in both water and hydroxyapatite. Concerning the bond strength, In comparison to conventional composite, the bond strength in flowable bulk fill composite was found comparable at 2 mm and higher than conventional composite at 4 and 6 mm. In regards to paste-like bulk fill composite, there was no study found in the literature aimed to assess the bond strength to dentine, according to the search strategy used in this review.

Conclusions: Although a perfect marginal seal is not achievable clinically, a good marginal quality should be the main aim for clinicians. Obtaining marginal integrity during filling cavities with composite materials determines pulp protection against microleakage.

Keywords: Composite, Dental pulp, Microleakage, Bond strength, Marginal integrity.

Introduction

Marginal microleakage first defined by Kidd in 1976 is a process consisting in clinically undetectable penetration of bacteria, their metabolites, enzymes, toxins, ions, and other cariogenic factors between the filling and the cavity wall [1]. Clinical consequences of microleakage are secondary caries, pulp inflammation, marginal discoloration, postoperative sensitivity, and the reduction of longevity of filling. It is believed that the existing occlusive load of the oral cavity and the thermal changes favour the formation of a marginal gap at the contact surface between the tooth and material [2]. Rising expectations of patients regarding the aesthetics of fillings have recently made the composite resins the most commonly used nowadays restorative materials of lost tooth tissues. This applies to aesthetic dental restorations not only in the anterior teeth but also in the posterior teeth, so that in many countries composites do have almost totally replaced amalgam as restorative in posterior teeth [3].

The gold standard materials for restorative dentistry are resin-based composites due to their characteristics. Dentists expect from modern technology a composite material with high aesthetic value, less polymerization shrinkage, perfect marginal integrity, and relevant physico-mechanical properties. Embedding a composite restoration in posterior teeth is generally a time-consuming activity. When extensive cavities are filled in posterior teeth, such a treatment can imply the risk of incorporating air bubbles or contaminants between the increments [4]. Due to high colour translucency of these materials, it is possible for the light to reach deeper but if the cavity is deeper than the maximum depth of cure 4 mm, it is necessary to apply another layer. Low shrinkage of these materials and high filler content cause shrinkage stresses to be very low and this allows for application of thicker layers [5]. The newly developed bulk-fill resins offer composites including low-viscosity (flowable) and high-viscosity material types [6]. Posterior Bulk Fill Flowable Base is a single component, fluoride containing, and visibly light cured radiopaque resin composite restorative material. Amongst many parameters defining the quality of materials that restore lost tooth tissues, marginal integrity seems to take part as the most important. During in vitro studies, various methods are used to detect the presence and assess the microleakage between the tooth tissues and filling material [7]. The anatomical basis of microleakage is based on the marginal gap between the restoration and the dental tissues. The clinical implications could be postoperative sensitivity, dentinal sensitivity, and development of secondary caries [8]. As highlighted by many studies a restoration that has a cement margin represents challenge for adhesive dentistry techniques.

in fact, the higher percentage of organic material (23%) of the root cementum, compared with enamel (1-2%), makes cementum a substrate that exhibits weaker and less predictable adhesion parameters [9]. Adhesion to cement/dentin is in fact the weak point of the adhesive restoration due to several factors: hydrolysis of the adhesive layer, inadequate infiltration of the adhesive into the substrate, and incomplete evaporation of the solvent. Some of these drawbacks can be modified by varying the type of adhesive strategy : for example, the use of functional monomers inside the adhesive makes possible to obtain an adhesive layer through the phenomenon of "nano layering" preventing hydrolytic degradation of the adhesive layer. It has been hypothesized that direct or indirect techniques and different cervical margin cavity types would have an effect on the occurrence of microleakage and gap formation in proximal resin composite [10]. This review aimed to investigate the problem of microleakage in composite filling, as well as the effect of microleakage on dental pulp.

Methods

An online search about relevant papers was conducted, which include PubMed indexed literature, was performed by combining the term "bulk fill" and “microleakage” using the AND operator, from time to time to the terms of class II, class III, and V to try to introduce the studies that referred to the design of the cavity. Keywords included “microleakage” OR "dental leakage" OR "cervical microleakage" OR "dental restoration failure" OR "mineral interfaces" OR "marginal quality" OR "gap formation" OR "tooth hypersensitivity" # 3 "Composite resins" OR "dental composites" OR "resin-based composite" OR "bulk fill" OR "resin composite" OR "bulk-fill" OR "composite resin" OR "composite resin" OR "SDR composite" OR "dental bonding" OR "dentin bonding agents" OR "dental cement" OR "resin cement". Additional searches were performed on Google scholar and semantic Scholar using the terms "bulk fill" and "microleakage".

The search strategy, performed using the PubMed controlled vocabulary and free terms, was defined on the basis of the following elements of the PICO question: The eligibility criteria are: in vitro or in vivo studies, published in the last 20 years (given the date of introduction of the material on the market) and written in English. It was decided to include studies on human teeth and in vitro studies to have a standardization of the cavity, which would not be possible to obtain in an in vivo study.

Results and discussion

A total sample of 384 attendants in PHC centers One of the major drawbacks of traditional composite materials is their polymerization shrinkage, which can also be considerable and can reach 3 to 7% of the initial mass, contributing to the formation of marginal gap [11]. The need for a material with low polymerization shrinkage has led to the development of a several resin-based composite materials (siloranes, ormocers, nano-filled composites) that exhibit lower polymerization shrinkage than conventional composites. However, they still need to be deposited in maximum increments of 2 mm due to their limited depth of polymerization and some are also impractical due to the need for a specific adhesive system [12]. A further improvement in the technology has led to the development of materials that have both a reduced polymerization shrinkage and an increased depth of cure (DOC) [13]. The combination of these two characteristics allows the material to be deposited in increments greater than 2 mm of the non-bulk composite. In 2010, the first resin-based composite was developed that could be deposited in increments of up to 4 mm [14]. This new class of materials is collectively referred to as "bulk fill resin-based composites." These composites are heterogeneous in composition and commercial presentation therefore a satisfactory classification is difficult, if not impossible. The positioning of a restoration with a cement margin represents a challenge for the clinician associated with the problem of time: the cervical area, in fact, is difficult to control and to access; moreover, it is difficult to maintain adequate isolation for a relatively long period. Therefore, the possibility of using a material that has optimized physical characteristics and also allows shorter processing times is fascinating [15].

The most essential factors determining preservation of restoration placed in a cavity are the marginal seal and absence of leakage [15]. If the material provides ease and short time of placement these are extremely desirable characteristics but significant advances in composite technologies are not so frequent. Manufacturers of composite materials, with a view to simplify the procedure of introducing the material into the cavity and its polymerization, now offer bulk-fill type composite resins. Simplification of procedures and shortening the time of embedding bulk-fill type restorations are due to possibility of applying a single up to 4 mm composite increment and it makes the work quicker by reducing the number of clinical steps [16]. The innovative system of polymerization initiation determines shortening of light-curing time and increasing the depth of cure. The time of colour matching process is shorter because of universal colour of materials and shorter time of finishing and

Table (1): Physical properties related to microleakage among composite fillings

Composite properties	*study*	*Measurements*
Bond strength to dentine	[24]	(MPa, medians at 2 mm/4 mm/6 mm): -SDR = 24.6 /22.7 /23.4, -FBF= 21.4 /20.3 / 22.0,
Marginal adaptation	[25]	Gap, micrometer: (median, range): -Venus Bulk Fill=Median, 10.2* Range, 3.6-31.7 -SDR, =Median, 6.1, Range, 3.3-33.0 x-tra base= Median, 9.3*, Range, 5.2-36.6
Microleakage	[26]	The cervical microleakage scores for the eight MOD cavities: SDR=1.875 x-tra base=2
	[23]	Dye leakage around examined restorations N(%): **0 score**= (Filtek, SDR) (86,66%) (93,33%) **1 score** (Filtek ,SDR) (3,33%) (3,33%) **2 score** (Filtek ,,SDR) 0 6,66%), (3,33%) **3 score** (Filtek ,,SDR) (3,33%),(0%)
	[22]	Enamel microleakage with clearfil bonding N(%): **0 score**= SDR=56% **1 score=SDR=25%** **2 score** =SDR=19% **3 score** =SDR=0%
	[22]	Dentine with clearifil bonding microleakage N(%): **0 score**= SDR=75% **1 score=SDR=25%** **2 score** =SDR=0% **3 score** =SDR=0%

polishing of the restoration was noticed [17]. Nevertheless an ideal bulk-fill composite would be one that could be placed into a preparation having a high C-factor design and still exhibited very little polymerization shrinkage stress, while maintaining a high degree of cure throughout . It has handling characteristics typical of a flowable composite but can be placed in 4 mm increments with minimal polymerization stress. SDR has a self-levelling feature that allows intimate adaptation to the prepared cavity walls. Shrinkage stress compensation mechanism, in some bulk-fill composite materials, was obtained using a resin having low shrinkage properties and high around 84% filler content [18]. Other bulk-fill materials contains in its composition an inhibitor of sensitivity to light and thus provides prolonged time for modelling of filling, an inhibitor of shrinkage stress in order to achieve optimal marginal seal, as well as polymerization photo-initiator allowing curing of 4 mm layers of material. A clinical evaluation of the new bulk-filling technique is important to observe the anatomical shape and marginal adaptation and margins discoloration [19]. Although a perfect marginal seal is not achievable clinically, a good marginal quality should be the main aim for clinicians. Obtaining marginal integrity during filling cavities with composite materials determines pulp protection against microleakage. The polymerization reaction of light-cured composites is faster than that of self-cured composites, which leads to the development of higher setting stresses than self-activated materials. Furthermore, the maximum stress generated at the cavity wall in light-cured composite restorations is twice as large as that seen for self-cured composite restorations [20]. The micro-tensile bond strength of resin composite bonded to a box-like Class I dentin cavity was demonstrated to be reduced as a function of the cavity configuration and depth.

Regarding cavity preparation, using a less traumatic system such as laser systems may be favourable in paediatric dentistry. These lasers can ablate enamel and dentin more effectively due to the highly efficient absorption in both water and hydroxyapatite. The ability of Er:YAG laser to remove enamel and dentin was found comparable to that achieved with the conventional dental drill and produces minimal thermal damage to the pulp or surrounding tissues, especially when irradiated with continuous water spray. Animal histological studies showed that pulpal response to the Er:YAG laser appears to be similar to the response from high-speed hand piece application. When dental hard tissues were irradiated by the Er,Cr:YSGG laser accompanied with a water spray, not only could the temperature be suppressed, but cutting efficiency could be increased. Studies on surface alterations of the enamel and dentin after Er,Cr:YSGG laser irradiation shows that these surfaces are associated with micro-irregularities and there was also the absence of a smear layer. It is possible that alterations of the surface textures of enamel and dentin after Er,Cr:YSGG laser irradiation may affect microleakage of restorative materials in primary teeth. The result of microleakage scores found in this study. J/cm 2) because the removal of enamel tissues was more difficult with this laser device. Cutting the enamel by laser has a lower efficiency than cutting the dentin due to less water and organic contents of enamel structures [21].

Concerning the bond strength to dentine in bulk fill composite was assessed by only one included study at different depths (2, 4, and 6 mm) (Flury et al., 2014). The median bond strength to dentine measured in Mpa ranged 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. In comparison to conventional composite, the bond strength in flowable bulk fill composite was found comparable at 2 mm and higher than conventional composite at 4 and 6 mm. In regards to paste-like bulk fill composite, there was no study found in the literature aimed to assess the bond strength to dentine, according to the search strategy used in this review. The marginal adaptation of flowable bulk fill composite was assessed by only one included study (Benetti et al., 2015). Median of marginal gap in micrometer ranged from 6.1 to 10.2. The same study assessed the marginal adaptation of paste- like composite, and they found a median gap ranged from Gap 6.6 – 7.1 micrometer. There was no comparison made to the conventional composite. The micro-leakage is usually assessed according to the following scores, score 0 = no micro-leakage, score 1 = Leakage ≤ 1/2 length of occlusal/gingival walls, score 2 = Leakage ≥ 1/2 length of occlusal/gingival walls, score 3 = Leakage that covers entire length of occlusal/gingival walls and also involves the axial wall. In this review, two included studies assessed the micro-leakage of bulk fill composite filling using these scores [22, 23].

Only two included studies assessed the micro-leakage of flowable bulk fill composite, Orłowski et al. found low levels of micro-leakage, where no micro-leakage reported in 86.7% - 93.3% of studied specimens, while score 1 was found in 3.3%, score 2 in 3.3% - 6.7%, and score 3 in 0.0% - 3.3% of studied specimens. Arslan et al. studied micro-leakage in enamel and dentine with the bonding agent, and they found higher levels of micro-leakage than those found by Orlowski et al. No micro-leakage was found in 56% of enamel specimen and 75% of dentinal specimens, while score 1 micro-leakage was found in 25% of both enamel and dentinal specimens. Score 2 micro-leakage reported in 19% of enamel specimens only, and no specimen reported score 3 micro-leakage. In comparison to conventional composite, 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. However, the dentine micro-leakage was higher than conventional at score 0, equal at score 1 and 3, lower than conventional at score 2. In regards to paste-like micro-leakage, only one included study assessed the extent of micro-leakage using dye penetration [23]. They found no micro-leakage in 73% - 90% of studied specimens (which was lower than flowable bulk fill composite). In addition, they found score 1 micro-leakage in 3.3%-23.3% of studied samples, while score 2 and 3 were found in only 0.0%-6.6% of studied samples. There was no comparison made to the conventional composite.

Conclusions

The bond strength to dentine in flowable bulk fill composite was comparable or higher than conventional depend on increase in the filling thickness, no study assessed the bond strength in paste-like composite. In marginal adaptation, no comparison to the conventional composite was made. Concerning micro-leakage, the bulk fill composite was comparable to the conventional composite in enamel, but lower than conventional in dentine.

Conflict of interests

The authors declared no conflict of interests.

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