EFFECT OF FILLING TECHNIQUE ON COMPRESSIVE STRENGTH OF CLASS II COMPOSITE RESTORATIONS

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ABSTRACT

Aim of the study This study aimed to evaluate the effect of filling technique on class II composite restoration`s compressive strength. **Materials and methods** Thirty human maxillary molars were prepared with standardized class II cavities and divided in two groups (n=15): the control group restored by incremental oblique filling technique and the study group restored by bulk filling technique, using the same composite resin (Filtek Bulk Fill Restorative, 3M ESPE, Saint Paul, Minnesota, USA). The specimens were subjected to a compressive load in universal testing machine until fracture and failure mode was analysed. The results were statistically processed with the software Epi Info 7.2 and Microsoft Excel 2019, and the significance level was set at 5%. **Results** There were no statistically significant differences in the compressive strength of performed restorations using the incremental or bulk filling technique. The failure type IV (root failure beyond repair) presented the bigger proportion for both groups, with no significant statistical difference. **Conclusions** With the bulk-fill composite evaluated, the restoration technique, incremental or bulk-fill, does not significantly affect the compressive strength of class II composite restorations.

Key words: composite restoration, compressive strength, filling technique.

INTRODUCTION

Composite resins opened new horizons in operative dentistry and now are the materials of choice with predictable results for direct restorations due to strong adherence to dental hard tissues via adhesive techniques [1,2]. Based on the concept of patient-centered and evidence-based practice, the purpose of general practitioners is to mimic, as possible, the natural dentition in a comprehensive and simple way by delivering functional, biological and esthetic restorations and by conserving tooth structure and vitality [3-5]. For this reason, restorative materials are paramount to improve the biomechanical behavior of a cavitated tooth, by providing stresses transmission through not only the dental substrates, but also within the body of the restored system [6]. Through this point of view, performing direct composite restorations is a great challenge for a dentist and clinical observations of posterior restorations found an annual failure rate ranging from 0 % to 5.4 % [7]. To increase the longevity of direct restorations, those reasons that lead to failure must be considered, and for the posterior teeth the main causes are secondary caries and fracture of the tooth or/and restoration [8-10].

The incremental, named also layering filling technique, is the standard protocol in clinical practice and was considered a cornerstone in most dental schools worldwide. It supposes placing and light-curing a composite up to 2 mm layers thickness [11]. While horizontal, vertical and

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oblique increments have been proposed, all have the same goal of providing an adequate photopolymerization of each increment and reducing of polymerization shrinkage stress [12-14].

Unfortunately, incremental filling technique has some disadvantages. It requires more attention to details during placement of each layer, so it is technique-sensitive and time-consuming. In extended or deep cavities, it determines an implicit risk of incorporating impurities or air bubbles between layers [13,15]. By creating voids and small defects, the overall strength of the restoration overtime will be reduced due to crack propagation, leading to premature failures [16,17].

To overcome some of these problems, bulk filling technique was developed by using bulk-fill composites, inserted in an increment up to 4-5 mm thickness [15]. The last ones have been popular among clinicians due to decreasing the number of composite layers and thus the curing and operative time, simplifying the restorative procedure and reducing the risk of contamination, the internal gaps and defects within the restoration [18,19]. Also, some studies reveal that when tested in vitro, some bulk-fill materials showed similar or better performance in polymerization stress, cuspal deflection, marginal adaptation, degree of conversion, flexural strength, and fracture strength compared to conventional composite resins [20,21].

To increase monomer conversion and polymerization rate, additionally, composite preheating is suggested [22]. It enhances marginal adaptation of the restoration and reduces interfacial gap percentage and void volume, offering an efficient approach for improving clinical outcomes [23-25]. In vitro studies of the influence of preheating on the mechanical properties of the composite found that it increases microhardness [26,27].

Despite all this data, when comparing conventional resin composites with bulk-fill composites, there is still much controversy surrounding this topic.

For this reason, the aim of this study is to evaluate the effect of filling technique on class II restoration compressive strength. The null hypothesis is that there is no difference in the resistance to compressive forces when the restoration is applied by incremental filling technique and bulk filling technique, using the same composite resin.

MATHERIALS AND METHODS

Teeth selection and cavity preparation

For the study, thirty human maxillary molars, with a maximum difference of 22% in size, were chosen and stored in distilled water up to 3 months. The criteria for teeth selection were the absence of caries, fractures, fissures and previous restorations. To remove organic and inorganic remnants, cleaning of the teeth was performed with periodontal curretes, by manual scaling. A prophy paste was used for brushing.

The teeth were inserted in a silicone square mold (1.5x1.5x1 cm) using an acrylic resin (Paladur, Kulzer, Hanau, Germany) up to 2 mm below the cemento-enamel junction.

Class II mesio-occlusal cavities were prepared in all specimens, providing a box preparation. A digital caliper (Test Tool Series, Tacklife, Shenzhen, Guangdong Province, China) and a periodontal probe (PerioWise Periodontal Probes 3-5-7-10mm, Premier Dental Products, Plymouth Meeting, Pensilvania, USA) were used to standardize the cavities as follows: buccal-oral width of 5 mm, occlusal-cervical height of 5 mm and occlusal depth of 4 mm (Fig. 1). The cavity preparation was performed using diamond burs (5837.314.014, Komet Dental, Lemgo, Germany), under microscopic visualization. The burs were replaced every five preparations and were used at high speed,

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under constant water-cooling.

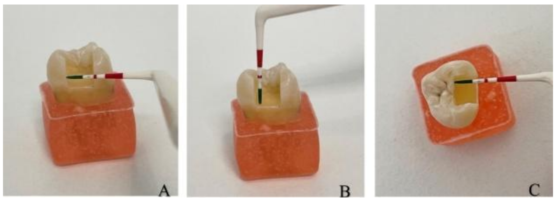

Figure 1. Standardized cavities: A. buccal-oral width of 5 mm B. occlusal-cervical height of 5 mm C. occlusal depth of 4 mm

Restorative filling techniques

The teeth were randomly divided into two groups (n=15), according the two filling techniques (Fig. 2):

1. The control group with fifteen teeth filled by incremental oblique technique: composite applied in five oblique layers.
2. The study group with fifteen teeth filled by bulk filling technique: composite applied in one increment.

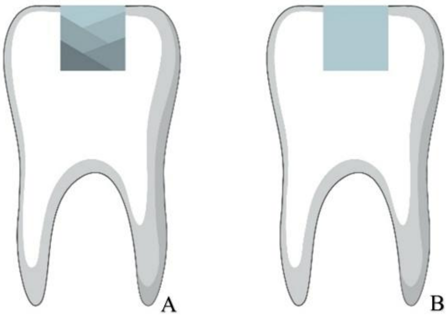

Figure 2. Groups of teeth included in the research: A. Incremental filling technique B. Bulk filling technique

Incremental filling technique:

1. Cavity preparation with diamond burs (5837.314.014, Komet Dental, Lemgo, Germany) according to established dimensions.
2. Adaptation of the transparent matrix fixed with toflemire to restore the proximal wall. The matrix served as a guide for the volume of composite resin and was a reference for the marginal ridge and for the occlusal-cervical height.
3. Selective enamel etching with orthophosphoric acid 35% (Ultra-Etch™, Ultradent, Utah, USA), for 20 seconds.
4. Cavity rinsing for 40 seconds and gentle drying.
5. Application of adhesive system (Clearfil SE BOND™, Kuraray, Tokyo, Japan) on the entire cavity (dentin and enamel) in 2 steps. Primer application and leaving it in place for 20 seconds, after that evaporation of volatile ingredients with a mild oil-free air stream. Bond application and making it uniform using a gentle oil-free air stream. Light-curing for 10 seconds with a dental curing light (Valo™ Cordless, Ultradent, Utah, USA).
6. Restoration of the cavity with bulk-fill paste composite in capsules (Filtek Bulk Fill Restorative, 3M ESPE, Saint Paul, Minnesota, USA): application of the layers as was specified and polymerization of each layer for 20 seconds from occlusal part (Fig. 2A).
7. Removing the matrix, finishing and polishing the restoration with discs (Sof-Lex, 3M ESPE, Saint Paul, Minnesota, USA).

Bulk filling technique:

All steps, materials, and technical execution were the same as described for the incremental technique, except for the placement and light-curing of the composite resin.

6. Restoration of the cavity with bulk-fill paste composite in capsules (Filtek Bulk Fill Restorative, 3M ESPE, Saint Paul, Minnesota, USA), previously preheated at 68oC (Voco Caps Warmer, Voco, Cuxhaven, Germany): injection in one layer and polymerization 20 seconds from occlusal part, 20 seconds from buccal part and 20 seconds from oral part (Fig. 2B).

Compressive strength test

Teeth were preserved in distilled water at the room temperature for 7 days until load testing. After that, the fracture strength test

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was performed in a universal testing machine (AUTOGRAPH, AG-1, 5kN, SHIMADZU, Kyoto, Japan). The specimens were subjected to a compressive load using a metal rod in contact with the composite occlusal part, placed in the middle of the buccal-lingual width and at 1 mm from the marginal ridge (Fig. 3). The load was applied with speed of 1 mm/min, parallel to the long axis of the tooth, by recording the maximum force (N- Newtons) in an electronic program.

Figure 3. Universal testing machine and a specimen subjected to a compressive load

Failure mode of tested teeth

All the specimens were analyzed for the failure mode and classified into one of the four categories as follows: (I) failure at composite resin, (II) failure at composite resin and coronal tooth structure, (III) failure at composite resin and cervical tooth structure with possible periodontal repair and (IV) root failure beyond repair.

Statistical analysis

The test results of the two groups were subjected to statistical evaluation with the software Epi Info 7.2 and Microsoft Excel 2019 to establish statistical differences between the analyzed groups. For this, CI – 95% was calculated. The significance level was set at 5% for all the tests. To obtain the p-value was used T-student test, which compares two mean values and shows if they are different from each other.

RESULTS

The teeth of both groups were selected for tooth dimensions evaluation. In the case of the study group, the average of mesio-distal dimension was 8.1±0.4 mm, with minimum of 7.1 mm and maximum of 9.1, and median and modulus were 8.1 and 8.0 mm, respectively. About buccal-oral size the average was 7.7±0.6 mm, with minimum of 7.0 mm and maximum of 8.8 mm, and the median and modulus were determined to be 7.6 mm and 7.0 mm. In the control group, the average of mesio-distal dimension was 8.3±0.7 mm, with the minimum of 7.3 mm and the maximum of 9.9, and the median and modulus were 8.3 and 7.3 mm, respectively. The average of buccal-oral size was 7.4±0.6 mm, with a minimum of 6.8 mm and a maximum of 8.8 mm, and the median and modulus were established to be 7.2 mm and 7.1 mm (Table I).

In accordance with the purpose of the study, compressive force (measured in Newton) was applied to both groups of selected teeth (Table II). Thus, in total, a force of 21086.6 N was applied to the study group, with an average of 1405.8±206.7 N per tooth. The minimum of the applied force was 1025.1 N, and the maximum 1707.7 N, with the median and the modulus determined to be 1427.2 N and 1025.1 N, respectively. In the control group, the indicators were practically similar (without significant statistical differences between the two groups – $p \geq 0.05$), as follow: total applied force was 20052.0 N, the average force was 1336.8±210.2 N per tooth, the lowest applied force was 985.2 N, and the highest was 1709.7 N, with the median and the modulus 1382.8 N and 985.2 N, respectively.

Tabel I. Statistical characteristic of tooth sizes from the two groups included in the study

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	Obs	Total	Mean	Std Dev	Min	Median	Max	Mode
MD dimension, mm, control group	15	124,2	8,3	0,7	7,3	8,3	9,9	7,3
BO dimension, mm, control group	15	111,2	7,4	0,6	6,8	7,2	8,8	7,1
MD dimension, mm, study group	15	121,2	8,1	0,4	7,1	8,1	9,1	8,0
BO dimension, mm, study group	15	115,1	7,7	0,6	7,0	7,6	8,8	7,0
Abbreviations: MD, mesio-distal; BO, buccal-oral.								

Tabe II. The statistical characteristic of the applied force in the two groups

	Obs	Total	Mean	Std Dev	Min	Median	Max	Mode
Maximum force S (N)	15	21086,6	1405,8	206,7	1025,1	1427,2	1707,7	1025,1
Maximum force C (N)	15	20052,0	1336,8	210,2	985,2	1382,8	1709,7	985,2

According to these results, the null hypothesis cannot be rejected, as no differences were found between the resistance to compressive forces when the restoration is applied by incremental filling technique or with a bulk filling technique, using the same composite resin.

As a result of applied force as presented in the data above, the fractures that occurred in the teeth were classified into four types numbered from I to IV with Roman numerals, with the proportion of each type of fracture (Fig. 4). Thus, in the study group type I fracture was recorded in 5 cases out of the 15 observations, which represents a proportion of 33.3% (CI 95%, 11.8-61.6), compared to them in the control group, this fracture type was established in 4 cases out of 15 observations, which forms 26.7% (CI 95%, 7.8-55.1). Further, type II fracture was established in the study group in 6.7% cases (CI 95%, 0.2-32.0), and in the control group in 13.3% cases (CI 95%, 1, 7-40.5). Fracture types III and IV had equal proportions in both groups, namely 13.3% (95% CI, 1.7-40.5) for type III and 46.7% (95% CI, 21.3-73 ,4) for type IV (Table III).

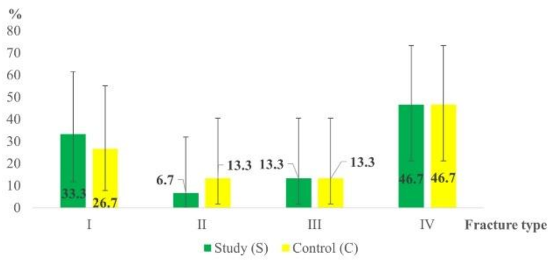

Figure 4. Graphic representation of fracture type distribution in two groups.

DISCUSSION

Even though resin composite materials are increasingly used in modern dentistry due to adhesion potential, esthetic appearance and good physical and mechanical properties, placing of dental composites can be a stressful experience, as each clinical case is different and requires knowledge and excellent practical skills [28]. The correct application of the technique is essential to

Table III. Comparative proportions of fracture types in the two groups

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Fracture type	Group			
	Study (S)		Control (C)	
	Frequency	% (CI 95%)	Frequency	% (CI 95%)
I	5	33,3 (11,8-61,6)	4	26,7 (7,8-55,1)
II	1	6,7 (0,2-32,0)	2	13,3 (1,7-40,5)
III	2	13,3 (1,7-40,5)	2	13,3 (1,7-40,5)
IV	7	46,7 (21,3-73,4)	7	46,7 (21,3-73,4)
Total	15	100,0	15	100,0

ensure successful results [29]. In addition, composite resins should exhibit, by themselves, mechanical strength suitable for use in high-stress-bearing areas, as posterior regions [28]. The compressive strength of a resin composite is an important indicator of fracture resistance and may be correlated with the occurrence of marginal or body fractures by mastication [30].

The results of this study should be interpreted considering the limitations inherent in the type of test model. The laboratory assessments do not directly reflect the real in vivo conditions. The teeth were collected from different patients, which can lead to significant histomorphological differences.

In the present study, evaluating the influence of restorative filling technique on compressive strength, it was established that there is no statistical significance between both groups. Class II restorations performed by bulk filling technique using bulk-fill composites resulted in similar resistance to compressive forces compared to incremental technique. Concerning the fracture resistance, incremental filling technique can be substituted by bulk filling one, as placing of one layer of composite is less time consuming, simplicity and quick modelling are achieved with good biomechanical results [31]. Another reason of satisfactory performance of restorations done by bulk filling technique is the potential reduction of defects and air bubbles incorporation, in this order without damaging the overall strength of the restoration. Also, composite preheating can contribute to the increase of composite microhardness both on the surface and at the base of the samples, with a predominance of the surface one [32]. This is conditioned by the fact that by increasing the temperature and the degree of conversion of the monomer, the polymerization speed also increases, resulting in better mechanical properties, and with the advancement in depth, the illumination decreases due to reflection, absorption and dispersion [16]. However, it cannot be established that the bulk filling technique is better for posterior composite resin restorations simply because it presents similar compressive strength to the incremental technique, associated with greater simplicity and shorter execution time. The clinical success of this type of restoration involves others important outcomes, namely marginal deterioration and marginal leakage, and the consequent recurrence of caries, which may be related to others important factors such as the shrinkage stress of composite resins.

Previous studies done on premolars underlined that bulk-fill resin composites demonstrated similar mechanical performance and reliability as compared with conventional resin composites [33]. Others biomechanical behavior researches showed that bulk-fill resin composites promoted less

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polymerization shrinkage stress than conventional microhybrid composites, presenting a higher fracture strength, but with root and crown failure non-restorable. Also, less polymerization stress during photo-activation determines better dissipation and transmission of residual stress, bulk-fill composites acting as stress-absorbing agents [34]. A study done on class I restorations showed differences in fracture strength of teeth performed with different restorative strategies [3]. This statement is partially in accordance with our results since all the groups restored with bulk-fill composites exhibited similar compressive strength.

When submitted to a compressive load, composite resins suffer a "barrel" effect and expand until plastic deformation occurs [36]. The fracture analysis in the present study showed that in the comparative evaluation between the research groups of the fracture type proportions, no significant statistical differences were established. The bigger proportion for both groups was represented by the failure mode IV, with the root involvement, which is challenging to restore since surgical procedures may be needed, making treatment complex and time-consuming [37]. These results differ from other studies which underline that teeth restored with bulk-fill composites present less catastrophic fractures than teeth restored with conventional resin composite, but in this case the comparison between the materials and not the filling techniques is established [38].

Regarding the clinical success of posterior composite resin restorations, concerning the influence of different restorative methodologies and materials, a combination of different pre-clinical assessment and screening protocols, followed by subsequent clinical research should be implemented to achieve greater predictive potential for an evidence practice dentistry.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be underlined:

1. There is no difference in the resistance to compressive forces when the restoration is applied by incremental oblique filling technique and bulk filling technique, using the same bulk fill composite.
2. The fracture mode is not influenced by the restorative filling technique, when it is used the same bulk fill composite.

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