INFLUENCE OF FILLING TECHNIQUE AND BEVEL PREPARATION ON MARGINAL SEALING OF CONVENTIONAL AND LOW SHRINKAGE COMPOSITE RESTORATIONS

ABSTRACT

AIM: The aim of this study was to evaluate two composite restorations (conventional methacrylate-based and low shrinkage-based silorane), associated or not to beveling and incremental technique, in relation to the microleakage and marginal gap formation tests. **MATERIAL AND METHODS:** 30 sound human molars had their mesial and distal surfaces prepared with and without bevel. The teeth were divided into six groups according to the type of resin (conventional nanofilled or silorane resin), and restorative filling technique (incremental technique or builk). Microleakage and marginal gap formation data were statistically analyzed by Kruskal-Wallis and Chi-Square tests, with a significance level set at 5%. **RESULTS**: Group 1 (Z350 XT, without bevel, incremental technique) presented highest rate of microleakage and marginal gap in most of the restorations, with statistically significant differences. Groups 4 and 6 (P90, beveled, builk and P90, beveled and incremental technique) had lower rates of microleakage and absence of marginal gaps in most of the restorations. **CONCLUSION**: It's concluded that the silorane showed lower rates of marginal gaps and microleakage, when compared to the conventional methacrylate-based resin. Bevel preparation was effective in reducing microleakage and marginal gaps for both resins used. Incremental technique was not necessary when associated with low shrinkage composite resin.

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KEYWORDS

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INTRODUCTION

Since the emergence of restorative composite resins in 1963 by Bowen[1], diverse technological developments have significantly improved the clinical performance of these restorative materials. However, the common chemical basis of most composites remains a radical polymerization using acrylates or methacrylates, which have significant polymerization shrinkage[2,3]. The composite resins, despite its great aesthetic properties, present limitations to its use as a restorative material in posterior teeth[3,4]. Problems resulting from polymerization shrinkage inherent to methacrylate always make dentists seek alternative techniques of polymerization and insertion of the composite into the cavity to minimize potential failures. Recently, silorane-based composite resin as organic matrix was introduced in market. This new molecule was developed with the aim to decreasing the polymerization shrinkage and its undesirable effects[5-7].

The polymerization shrinkage stress and the appearance of cracks in resin composite restorations are the cause of marginal discrepancy along time[8]. The silorane technology was developed to minimize a contraction and, therefore, decrease the tension developed. Many alternatives have been created to minimize the unwanted effects of polymerization shrinkage, such as beveling the enamel margins[9], specific insertion techniques[10], light curing methods[11], the development of new and effective dentin-bonding agents and, more recently, the introduction of the low polymerization shrinkage resins[12,13].

The silorane resin-based appearance rescued the discussion about the restorative filling technique, the influence and importance of dental cavity preparation and the valorization of the laboratorial tests to evaluate the performance of the restorative material to certify its use in clinical studies. Yamazaki et al.[14] (2006) showed that the incremental technique is still important, even to low shrinkage composite resins. Meanwhile, Santos et al.[15] (2013) showed less microleakage rates in dentin walls for a silorane-based resin in comparison to a conventional resin.

According to the new possibilities suggested by the literature, the use of low shrinkage resins can be a safe and feasible alternative regarding the direct restoration of posterior teeth. However, considering the recent emergence of the silorane-based restorative system and the lack of information available in literature, this study aims to disclose its performance in relation to the marginal sealing ability, influenced by different cavity preparations and filling techniques.

Therefore, the aim of this study was to perform a comparative evaluation of composite resin restorations with conventional methacrylate-based resin and low shrinkage-based silorane, associated or not to beveling and incremental filling technique, in relation to the microleakage and marginal gap formation tests.

MATERIAL AND METHODS

To evaluate the marginal sealing of conventional and low shrinkage composite resins, 30 thirds sound molars extracted for therapeutic reasons were selected (research protocol approved by the Ethic Committee of UFRGS, nº 8157). The teeth were disinfected by autoclaving for 15 minutes at 121°C[16], before using. Each tooth received standard proximal cavities with the follow dimensions: 2-mm mesial-distal range and 3-mm buccolingual distance, and the cervical walls were located in cementum/dentin (1-mm below the cementum-enamel junction). All cavities were made by carbide burs #245 (KG Sorensen, Alphaville, Brazil) in high speed with water-cooling spray. Every 5 cavity preparations the bur was replaced by another, totaling 60 preparations (n=10)[17]. The type of preparation differed only in relation to the cavosurface margin (with or without a straight bevel). The bevels were confectioned in 45º with a diamond bur #2135 (KG Sorensen, Alphaville, Brazil) with 1-mm of extension in thirty cavity preparations. Two composite resins were selected for restorations: conventional nanoparticulate (Filtek Z350 XT-3M/ESPE, shade A2, St. Paul, MN, USA) and silorane-based (Filtek P90-3M/ESPE, shade A2, St. Paul, MN, USA), as seen in table 1.

The teeth were divided into 6 groups according to the composite resin and restorative technique: Group 1: Z350 XT, without bevel and incremental technique; Group 2: Z350 XT, with a bevel and incremental technique; Group 3: P90, without bevel and builk; Group 4: P90, with a bevel and builk; Group 5: P90 without bevel and incremental technique; Group 6: P90, with a bevel and incremental technique.

The adhesive system used was the conventional 3-step (Scotchbond multipurpose-3M/ESPE, St. Paul, MN, USA) for the conventional resin; and the 2-step self-etching primer and adhesive for silorane-based resin.

For groups 1 and 2, the tooth surfaces were etched with 37% phosphoric acid for 15 seconds in dentin and 30 seconds in enamel , then washed for 15 seconds and wiped slightly with absorbent paper, the primer was applied for 20 seconds in dentin with microbrush followed by a gentle air drying for 5 seconds, and the application of the adhesive in dentin and enamel forming a thin film on the surface prepared with a microbrush, and then a photopolymerization (Gnatus, Ribeirão Preto, SP, Brazil) with power of 600mW/cm², calibrated on radiometer (Demetron, São Paulo, SP, Brazil) for 20 seconds.

For groups 3 to 6, cavities received an application of Filtek silorane primer with a microbush actively for 15 seconds followed by a gentle air drying for 5 seconds, then a light curing for 10 seconds. After that, Filtek silorane adhesive was applied and light-curing for 10 seconds.

Table 1. Materials used and their composition.

RESINS	COMPOSITION
Filtek Z350 XT-3M/ESPE shade A2	Bis-GMA, DMA, TEGDMA, Bis-EMA
Filtek P90 XT-3M/ESPE shade A2	Siloxanes + Oxiranes = Silorane, camphorquinone and iodonium salt
ADHESIVE SYSTEMS	**COMPOSITION**
Scotchbond Multi-Purpose (3M/ESPE)	1 (Acid): 37% Phosphoric Acid 2 (Primer): Aqueous solution of 2-hydroxyetyl methacrylate (HEMA) and an acid opolymer polialcenóico 3 (Adhesive): Solution of bisphenol diglycidyl dimethacrylate (Bis-GMA), 2-hydroxyethyl methacrylate (HEMA) and camphorquinone
Silorane adhesive system (3M/ESPE)	Primer: phosphate methacrylate, hydrophilic monomers, carboxylic acid. Bond: methacrylate, water, ethane, hydrophobic monomers

The resin was inserted into the cavity with the aid of composite instruments, in groups 3 and 4 was used a builk of 4-mm, then light-curing. In groups 1, 2, 5 and 6 the incremental technique was performed, with 2-mm each, then light-curing for 20 seconds. After all restorations conclusion, material excess was removed using #12 scalpels and restorations were polished immediately using Enhance system (Dentsply, York, PA, USA).

MARGINAL MICROLEAKAGE:

The restored teeth were thermocycled (CDC-BIO laboratory, UFPel) at temperatures of 5°C and 55°C, 500 cycles with 30 seconds in each temperature.

After, the same teeth were protected by nail varnish, except 1-mm around the restorations and they were placed in a container with distilled water for 24 hours and conserved in immersion on Rhodamine B dye for over 24 hours. Then, teeth were washed and sectioned in a mesio-distal direction. Each restoration was divided into its long axis with diamond disk, to measure the marginal microleakage at the cervical wall. Table 2 shows the scores of graduation of microleakage at the cervical margin that were used.

The analysis was performed using a stereoscopic microscope (40x-Laboratory of

Biochemistry and Microbiology Oral, UFRGS) by a single calibrated examiner.

Table 2. Scores of the marginal microleakage test.

SCORES	MARGINAL MICROLEAKAGE
0	No microleakage
1	Microleakage in enamel
2	Microleakage in the external half of the dentin
3	Microleakage in the internal half of the dentin
4	Microleakage in axial wall toward the pulp

MARGINAL GAP FORMATION:

The surfaces of composite resin were finished with sequential sandpaper water granulation of 100, 320 and 600. Then, the specimens were etched with 37% phosphoric acid for 1 minute, washed and dried, to clean the surfaces. The preparation of specimens for visualization at scanning electron microscope (SEM – JEOL JSM-6060, Japan), included the procedures of fixation, dehydration and metallization. After preparation, each specimen was observed in a SEM (Microscopy Laboratory of CME-UFRGS) with a magnification of 1500x to evaluate the presence or absence of marginal gap along the cervical wall of the restorations.

DATA ANALYSIS:

The data obtained of microleakage were tabulated and subjected to statistical analysis by Kruskal-Wallis non-parametric test, with a significance level set at 5%.

The data obtained in the presence or absence of marginal gap was tabulated and subjected to statistical analysis by Chi-square test, with a significance level set at 5%.

RESULTS

The data regarding to the marginal microleakage test were tabulated and subjected to statistical analysis using the Kruskal-Wallis test, with a significance level set at 5%. Differences among groups were identified through the Student-Newman-Keuls (SNK) multiple comparisons test (Table 3).

The results demonstrated that group 1 (Z350 XT without bevel, incremental technique) has the highest rate of marginal microleakage, with statistically significant differences in relation to the others. Groups 3 and 5 (P90 without bevel builk and P90 without bevel, incremental technique) did not differ from each other, but they have statistically significant differences compared to the other groups, with a lower rate of microleakage than group 1. Group 2 (Z350 XT, with a bevel, incremental technique) showed a statistically significant difference compared to the others, having a lower rate of microleakage than groups 3 and 5. Groups 4 and 6 (P90, with a bevel, builk and P90, with a bevel, incremental technique) did not differ from each other and they were the ones who had the lowest marginal microleakage, with statistically significant difference to the other groups.

The data analysis regarding to marginal gap formation was tabulated and statistically analyzed using the Chi-Square test, with a significance level set at 5% (Table 4).

Table 3. Data analysis of marginal microleakage test.

Groups	**n**	**Microleakage Scores 0/1/2/3/4**	***p***	**SNK (5%)†**
G1 – Z350 xt, no bevel, incr.	10	0/0/2/5/3	0.002	A
G2 – Z350 xt, bevel, incr.	10	4/2/4/0/0		C
G3 – P90, no bevel, builk	10	0/4/1/3/2		D
G4 – P90, bevel, builk	10	5/4/1/0/0		B
G5 – P90, no bevel, incr.	10	0/6/1/1/2		D
G6 – P90, bevel, incr.	10	7/2/1/0/0		B

†SNK- Student-Newman Keuls test.

Table 4. Data analysis of marginal gap formation.

Groups	**Gap**			
	Presence	Absence	**Total**	***p***
G1 – Z350 XT, no bevel, incremental.	9 (90%)	1 (10%)	10 (100%)	0,011
G2 – Z350 XT, bevel, incremental.	2 (20%)	8 (80%)	10 (100%)	0,058
G3 – P90, no bevel, builk.	6 (60%)	4 (40%)	10 (100%)	0,527
G4 – P90, bevel, builk.	1 (10%)	9 (90%)	10 (100%)	0,011
G5 – P90, no bevel, incremental.	4 (40%)	6 (60%)	10 (100%)	0,527
G6 – P90, bevel, incremental.	1 (10%)	9 (90%)	10 (100%)	0,011

The results demonstrated that group 1 (Z350 XT without bevel, incremental technique) showed marginal gaps in most of the restorations, with statistically significant differences when compared to the others (p=0.011). Groups 4 and 6 (P90, with a bevel, builk and P90, with a bevel, incremental technique) showed absence of marginal gaps in most of the restorations, with statistically significant differences in relation to the others (p=0.011).

There were no statistically significant differences between groups 2, 3 and 5 (Z350 XT, with a bevel, incremental technique; P90 without bevel, builk and P90 without bevel, incremental technique, respectively), in relation to the formation of marginal gaps.

Illustrative images of presence and absence of marginal gaps obtained in the scanning electron microscopy can be seen on figure 1 and figure 2.

Figure 1. Marginal gap in dentin specimen in group 1 (Z350 xt without bevel, incremental technique).

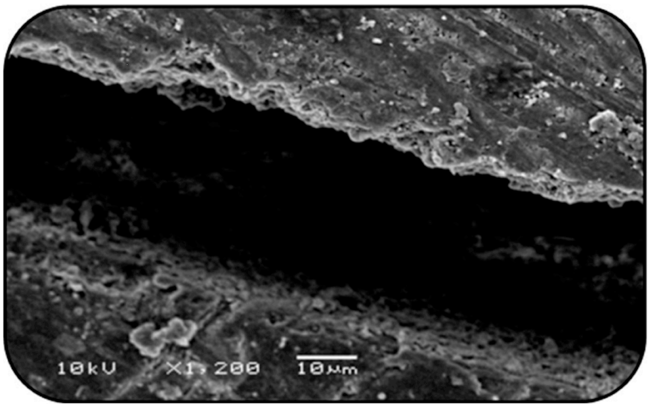
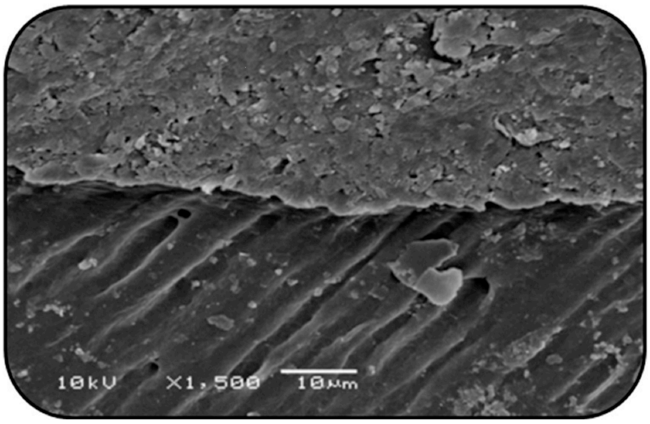


Fig. 2 Absence of marginal gap in dentin specimen in group 4 (P90, with bevel, builk).



DISCUSSION

New alternative materials and restorative techniques have been studied and applied in order to reduce the negative effects of polymerization shrinkage and to provide better adaptation of the material to cavity walls, best sealing and increase the useful life of composite restorations[7,13,18,19].

The present study determined the marginal sealing capacity of the composite material based on a new chemistry matrix composition. The silorane monomer was developed to overcome some disadvantages related to polymerization of methacrylate-based composites, the inhibition oxygen radicals, the polymerization shrinkage, the stress polymerization and the water sorption[6,19-21].

Thus, the reduction in water absorption, solubility and diffusion, caracteristics associated with the smaller diffusion coefficient of silorane, can potentially improve the hydrolytic stability of the composite resin restorations[17,22].

The effect of the polymerization contraction of the composite resin restorations in vitro was reported by Meredith and Setchell[23] (1997), Jantarat et al.[24] (2001) and Abbas et al.[25] (2003). The silorane-based material has the advantage of reducing the polymerization shrinkage, by oxirane-ring opening during the polymerization[26]. Silorane-based resins are alternatives to conventional methacrylate-based resins, because they have a lower water sorption and hydrophobicity due to the chemical characteristics of this material[17,19,22]. Although the restorative incremental techniques are widely accepted as the major responsible for the reduced C-factor and the stress resulting from polymerization shrinkage, this fact is based on the possibility of having less contact with the cavity walls and from reduction of the contraction obtained by the small volume of material[27]. However, despite these properties are valid for each individual increment, it is observed that the total contraction and stress developed are resulting from the combined effect of the contraction of all the amount of resin and the consequent deformation of the surrounding tooth structure. After the restoration is completed, the incremental restorative methods eventually induce the contraction stress, resulting in stress of surfaces adhered in the cavity walls[28,29].

Shrinkage, if not controlled, seems to be most responsible for the failure in marginal sealing[27,30-33]. This fact can overcome the adhesion to dentin and produce microcracks, according with Hassan et al.[34] (1987), responsible for the high rate of microleakage, especially when associated with class II cavities, with lower number of free surfaces to release tensions. When restored with lightcured composite resin that has lower flow capacity[32] in addition to cervical margins located in dentin/cementum, whose adhesion is weaker and unstable[35-37].

Some studies showed that the use of lining materials, mainly based on glass ionomer cement, is an effective method to reduce microleakage, based on reducing the volume of composite resin necessary to fill the cavity[38]. Nonetheless, the liners can increase the free surfaces of the cavity, reducing the stress generated on cavity walls during polymerization[27,30,33,35,39].

Although there are studies that associate the use of an incremental technique with decreased formation of cracks in the tooth/restoration interface and consequent reduction of microleakage[27,40], this was not observed in other experiments[18,37,41], as well as the results of the present study. However, the cavity size, the composite resin type and technique can be variables that influence on these results.

As demonstrated in the present study, the bevel made in cavosurface angle might be a useful procedure when performing composite restorations, and it can contribute to the relaxation of tensions originated from their own material shrinkage. The bevel is recomended to improve the quality of the restorations margins, as well as reduce the marginal infiltration and cracks[42]. The realization of a bevel has also been associated with beneficial results to composite restorations, both in posterior teeth and in anterior teeth, such: the cross-exposure of enamel prisms, the increasing of the area of surface to be etching, the increasing of surface energy and the wettability of the substrate, improving the adhesion, reducing microleakage[42], increasing the fracture resistance of the restored tooth[9], improving retention[43] and better esthetic results, masking the tooth/composite interface.

The results obtained in the study of Coelho-de-Souza et al.[44] (2010), with the employment of the bevel in posterior restorations, showed that despite influence on most of criteria: fractures and retention, marginal adaptation, postoperative hypersensitivity, recurrence of caries, brightness surface and anatomic form; were observed benefits in marginal staining, where the beveled restorations showed less staining than butt-joints[44]. Nevertheless, the results of the present study showed that the bevel can be associated with the reduction of marginal gaps and microleakage in the conventional and the low shrinkage resins.

In this in vitro study, statistically significant differences were detected among materials and techniques used. However, to long-term evaluations, clinical trials are excellent to provide scientific evidence of the durability and clinical effects of restorative procedures, using different materials, techniques of insertion and cavities designs[45].

Therefore, the challenge to minimize the tension of polymerization shrinkage and maximize the bond strength to dentin is still important and studied in restorative dentistry, which works to rehabilitate function, aesthetics, and promote an apropriate marginal sealing of the restorations[27,32].

CONCLUSION

Within the limitations of this study, it was possible to conclude that the silorane-based composite resin with low polymerization shrinkage (P90) showed lower levels of microleakage and marginal gaps compared to conventional methacrylate-based resin (Z350 XT). Bevel was effective in reducing microleakage and marginal gaps for both composites used (Z350 XT and P90). The incremental technique was not effective in reducing microleakage and marginal gaps, when associated with the low shrinkage composite resin (P90).

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