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Clinical Evaluation of Class I Restorations Made with Composite with Low Degree of Polymerization Shrinkage

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Authors' contributions

This work was carried out in collaboration between all authors. Author CRG designed the study. Authors CAN and MJM performed the statistical analysis. Authors PMRB and LKCFB wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Author VC managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this study was to clinically evaluate the performance of a conventional resin system and one with low polymerization shrinkage.
Study Design: A prospective, randomized, blind, split-mouth study.
Place and Duration of Study: Dental Clinic, division of Heath Sciencies, State University of West Parana - UNIOESTE/Brazil, between October, 2011 and October, 2012.

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Methodology: Teeth were restored with one of the two tested materials (n = 10): Conventional composite resin restorations (CCR) and Silorane-based resin composite restorations (SCR). The materials were used according to manufacturer's instructions. After time intervals of 30 days, 6 months and 1 year, the restorations were assessed using the USPHS criteria. The data obtained were tabulated and evaluated by the Chi-square test for clinical parameters and for the restoration criteria ($p < 0.05$).
Results: No statistically significant differences between the two composite resins were found, with exception of marginal adaptation, in which CCR showed better results than SCR.
Conclusion: The silorane-based composite resin showed no advantage over the methacrylate resin.

Keywords: Posterior restorations; polymerization shrinkage; marginal adaptation; composite resin.

1. INTRODUCTION

Resin composite has been the material of choice for esthetic restorations in both anterior and posterior teeth, because of its continuous technological advancement, minimally invasive restoration technique and capacity to reproduce the color of teeth.

These materials are basically composed of an organic matrix and filler particles. The resin monomer Bisphenol A-glycidyl dimethacrylate (bis-GMA) is the most common component of the organic matrix [1], which has a high viscosity. This makes it necessary to associate it with low molecular weight monomers such as the diluents: Ethylene glycol dimethacrylate (EGDMA) and triethylene glycol dimethacrylate (TEGDMA) to enable the incorporation of initiators, inhibitors and filler particles [2]. TEGDMA is the diluent most frequently used [3], however, its low molecular weight leads to an increase in polymerization shrinkage [4,5]. Therefore, other low viscosity monomers with high molecular weight, such as Urethane Dimethacrylate (UDMA) and Bisphenol-A dimethacrylate ethoxylate (Bis-EMA) have been used in various commercial formulations [6].

In order to reduce polymerization shrinkage, a silorane based resin composite - a new monomer system obtained from the reaction of oxirane and siloxane molecules - has appeared on the dental market, which has provided a lower level of polymerization shrinkage in comparison with dimethacrylate-based composites [7]. The literature has shown that silorane-based resin composites have a total volumetric shrinkage lower than 1% [8,9]. This is possible, since the silorane molecule has a central structure of siloxane with four interconnected oxirane rings, which open during polymerization to bind with the other monomers. Opening of the rings causes a volumetric expansion that partially compensates the shrinkage resulting from the molecular binding by means of covalent bonds [6].

With regard to the inorganic particles, resin composites may be classified as follows: conventional or macroparticulate; microparticulate resins; hybrid; microhybrid; nanohybrid and lastly, the nanoparticulate resin composites [10,11]. The organic matrix promotes an increase in wear resistance, color stability and resistance to staining [12].

One of the constant concerns with respect to the clinical longevity of resin composite restorations is the possibility of marginal leakage [13], which favors the occurrence of post-operative sensitivity, adjacent caries and marginal staining [13-15]. Thus, the aim of this study was to clinically evaluate the performance of a conventional resin system and one with low polymerization shrinkage, since the possible differences in the physical and mechanical properties exhibited by the resins, may contribute to the clinical success of the material.

2. METHODOLOGY

2.1 Ethical Consideration

This study was approved by the Ethics Committee on Research involving Human Beings of the State University of West Parana - UNIOESTE,/Brazil, report number 418/2011.

2.2 Study Design

It was prospective, randomized, blind, split-mouth study.

2.3 Place and Duration of the Study

It was conducted at the Dental Clinic, division of Heath Sciencies, on State University of West

Parana - UNIOESTE/Brazil, between October, 2011 and October, 2012.

2.4 Selection of Participants

2.4.1 Inclusion criteria

Ten patients were selected, involving a total of 20 teeth. The inclusion criteria were as follows: presence of caries in the occlusal region of posterior teeth; need for replacement of maladapted restorations, with marginal leakage or fractures, in Class I restorations.

2.4.2 Exclusion criteria

The exclusion criteria were: patients with parafunctional habits, pregnant women, those with systemic alterations or history of hypersensitivity to any product that would be used in the research.

2.5 Clinical Procedures

Anamnesis of the patient was performed, followed by clinical and radiographic exams, in order to prepare the treatment plan. The subjects were randomly assigned to one of the treatment groups. The randomization process was conducted before the clinical steps. The randomization procedure was carried out by using sequentially numbered opaque sealed envelopes prepared with unrestricted randomization [16]. Each treatment group and control group was written and sealed in envelopes before beginning the study. The dental operator who carried out all the treatments opened an envelope for each case at the beginning of the treatment.

Firstly, anesthesia was applied at the site of the tooth selected by the inclusion criteria. After this, moisture was controlled by rubber dan, of the operating field was performed. With a high or low speed instrument, all the carious tissue, or restoration considered unsatisfactory was removed from the selected tooth. After this, the teeth were restored with one of the two tested materials (n = 10): Conventional composite resin restorations (CCR) and Silorane-based resin composite restorations (SCR). The materials were inserted in the cavity, in accordance with the Manufacturer's specifications (Table 1). The sample size was determined by a previous pilot study.

2.6 Re-evaluation

The restorations were clinically evaluated after time intervals of 1, 6 and 12 months, by 3 previously calibrated evaluators. Photographic images were also taken with a professional camera (Canon EOS Rebel XTi- Tokyo, Japan). The criteria used for evaluation are shown in Table 2. In case of disagreement among the evaluators, a consensus was obtained with the aid of the photographic images.

2.7 Statistical Analysis

The data obtained were tabulated and evaluated by the Chi-square test for clinical parameters and for the restoration criteria ($P < .05$).

Table 1. Specifications of resin composites

Material	Composition	Instructions for use
CCR: Z350 (3M ESPE, Campinas, SP, Brazil)	Organic part: BIS-GMA, BIS-EMA (6), UDMA with small quantities of TEGDMA. Inorganic part: non-agglomerated nanoparticles of silica with a size of 20 nm, and nanoagglomerates formed of zirconium /silica particles ranging from 5 to 20 nm in size. The mean size of the agglomerates ranged from 0.6 to 1.4 micrometers. The quantity of inorganic filler particles was approximately 78.5% by weight or 59.5% by volume. All the colors were radiopaque.	Previous prophylaxis of the teeth; Color selection; Absolute isolation of the operative field; Class I cavity preparation; Acid Etching for 30s; Adhesive application with microbrush; Light polymerization for 20 seconds; Application of second layer of the adhesive system; Light polymerization for 20 seconds; Application of increments of approximately 2 mm in the cavity, followed by light polymerization for 20 seconds; Occlusal adjustment with Accu film extra-fine carbon paper to mark the contacts, and fine granulation diamond burs; Finishing and polishing.

Material	Composition	Instructions for use
SCR: P90 (3M ESPE, Campinas, SP, Brazil)	Silorane Resin; Initiator system: Camphorquinone, Iodonium salt, electron donor; Quartz particles; Yttrium fluoride; Stabilizers; Pigments	Previous prophylaxis of the teeth; Color selection; Absolute isolation of the operative field; Class I cavity preparation; Acid Etching for 30s; Active application of Filtek P90 (3M ESPE) primer with microbrush for 15s; Light polymerization of primer for 15s; Active application of Filtek P90 (3M ESPE, Campinas, SP, Brazil) adhesive with microbrush for 15s; Gentle application of air-jet; Light polymerization for 10s; First horizontal increment application uniting opposite walls, serving as lining; Light polymerization for 40s. Application of subsequent increments; Light polymerization for 40s. Occlusal adjustment with Accu film extra-fine carbon paper to mark the contacts, and fine granulation diamond burs; Finishing and Polishing.

Table 2. Evaluation criteria USPHS for direct clinical evaluation

Category	Evaluaton scale		Criterion
	Acceptable/Unacceptable		
Marginal adaptation	A		Undetectable by exploration
	B		Detectable gap (Exploratory probe sticks in both pathways)
		C	Obvious gap or fracture.
Anatomic shape	A		Undetectable gap
	B		Detectable gap in enamel only
		C	Detectable gap involving enamel-dentin
Marginal discoloration	A		Without discoloration
	B		Superficial stain (removable, usually localized)
		C	Deep stain
Caries formation	A		Without evidence of caries
		B	Evidence of caries
Post-operative sensitivity	A		Absence of post-operative sensitivity
		B	Post-operative sensitivity experienced at some time during restorative process, or study period.
Retention	A		Retained
	B		Partially retained
		C	Loss of restoration

3. RESULTS AND DISCUSSION

Table 3 shows the results obtained after a 1-year follow-up of the 20 restorations. Statistical analysis demonstrated that there were no statistically significant differences between the two types of resin composite, with exception of the criterion marginal adaptation, in which the silorane-based resin presented a detectable gap, and differed statistically from the nanoparticulate resin.

In this study, a clinical evaluation was made of Class I methacrylate and silorane-based restorations followed-up for one year. For this purpose, the USPHS clinical evaluation criteria was used, in which the follow items were evaluated: anatomic shape, marginal discoloration, post-operative sensitivity and caries formation. The results of the study revealed no statistically significant differences between the criteria evaluated for both composite resins, except for the criterion marginal adaptation, in which the composite resin Z350 was shown to be statistically superior when compared with composite resin P90.

Marginal adaptation may be influenced by polymerization shrinkage of the resin composite and adhesive system used [17]. The literature has shown that marginal adaptation is significantly increased in both clinical and laboratory studies, with the use of the conventional adhesive system, in which acid etching, followed by the primer and adhesive are used, when compared with self-etching systems [18].

This fact may have influenced the results of the present study, in which two different types of adhesives were used in this study according to the manufacturers' instructions.

Polymerization shrinkage of resin composite may be a strong harmful factor in the survival of direct restorations, with the result of stress being transferred to the bond interface [19]. There are other factors that may influence marginal adaptation, such as the wear and integrity of the bond interface, the C factor present in Class I cavities, which contributes to greater contraction stress. In addition, the technique of resin composite application in the cavity [20], isolation technique, type of light source of the light polymerizing appliance, or operator skill may also compromise the effectiveness of the bond. In this study, the technique of insertion in increments was used in all the restorations. This technique was shown to benefit the bond strength of both methacrylate-based and silorane-based resins [21].

Table 3. Distribution of scores according to the USPHS criteria

Criteria		P90			Z350		
		A	B	C	A	B	C
Marginal adaptation	2 months	10	0	0	10	0	0
	6 months	6*	4	0	10	0	0
	12 months	6*	4	0	10	0	0
Anatomic shape	2 months	10	0	0	10	0	0
	6 months	8	2	0	10	0	0
	12 months	8	2	0	9	1	0
Marginal discoloration	2 months	10	0	0	10	0	0
	6 months	8	2	0	9	1	0
	12 months	8	2	0	9	1	0
Caries formation	2 months	10	0	0	10	0	0
	6 months	10	0	0	10	0	0
	12 months	10	0	0	10	0	0
Post-operative	2 months	10	0	0	10	0	0
sensitivity	6 months	10	0	0	10	0	0
	12 months	10	0	0	10	0	0
Retention	2 months	10	0	0	10	0	0
	6 months	10	0	0	9	1	0
	12 months	10	0	0	9	1	0
Proportion of restorations	100 (10/10)			100 (10/10)			

** Statistically significant difference, P< .05*

In this sense, silorane was introduced in order to control polymerization shrinkage in posterior tooth restorations, with the purpose of overcoming some of the inconveniences related to the polymerization of methacrylate-based resin composites, such as the inhibition of oxygen radicals, polymerization shrinkage, polymerization stress, water sorption and the instability of conventional monomers in aqueous systems. According to information provided by the manufacturer, the silorane-based resin presented polymerization shrinkage of under 1%, however, recent studies found slightly higher values of volumetric shrinkage of Filtek P90 (1.4%) [22]. As demonstrated by the manufacturer, the mean polymerization shrinkage of the methacrylate-based resin Filtek Z350 was 2.09%, which would negatively influence the clinical performance of the restoration, however, this was not observed in the present study.

Nevertheless, some studies have shown that the reduction in polymerization shrinkage alone was not the only factor capable of improving marginal adaptation. Schmidt et al. [23] in an analysis of marginal adaptation exclusively, by means of a clinical study, related that methacrylate-based resin composite presented statistically better results in comparison with silorane-based resin composite, in agreement with the findings of the present study. Different results were found by Burke et al. [24] and Malhotra et al. [25] in which the resin with silorane presented good results for all the clinical evaluation criteria by the USPHS method. This may have occurred due to the fact that the authors used only the resin composite with silorane, without comparing it with another type of resin composite.

4. CONCLUSION

Based on the results of the present research, the silorane based resin composite presented clinically acceptable results after an analysis of one year, however, for the criterion marginal adaptation, the methacrylate-based resin composite showed clinically superior behavior.

CONSENT

All authors declare that written informed consent was obtained from the patient for publication of this paper and accompanying images.

ETHICAL APPROVAL

The protocol was approving by Bioethics Committee on Research involving Human Beings of the State University of West Parana - UNIOESTE/ Brazil, report number 418/201. All authors hereby declare that all experimnetn have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsink.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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