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Original Article

Microleakage of two types of low-shrinkage composite resins in class II cavities on primary molars

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Abstract

Introduction: In direct aesthetic restoration, microleakage resulting from polymerization shrinkage of resin composites is still challenging. Different strategies such as maximizing the amount of inorganic filler with prepolymerized filler and different silorane matrixes have introduced to overcome this issue. The aim of this experimental study was to compare the microleakage in low-shrinkage methacrylate-based (Clear fil AP-X) and silorane-based (Filtek P90) composite resins in class II cavities on primary molar teeth.

Materials & Methods: Classic class II slot cavity preparation was done on 60 healthy human primary molars. Specimens were randomly divided into two groups. For restoring the cavity in group I: methacrylate-based composite resin, and in group II: silorane-based micro-hybrid composite resin were used. The samples were thermocycled and soaked in 2% basic fuchsine dye for 24 h. They were longitudinally sectioned and observed at the gingival margins under ×10 magnification. Scores were assigned upon the amount of dye penetration. The Mann-Whitney U-test through SPSS19.0 was used for statistical analysis of data.

Results: In both groups, the major of samples showed score 0 of dye penetration. The comparison of gingival margin leakage indicated no significant difference between two groups.

Conclusion: Both restorative materials, irrespective of their type had microleakage. Given the comparable microleakage of silorane-based (Filtek P90) and low-shrinkage methacrylate-based (Clear fil AP-X) composite resins in Class II cavities of primary molars, the clinical efficacy of both materials seems to be similar.

Keywords: Silorane resins, Methacrylates, Composite resins

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میکرولیکیج دو نوع رزین کامپوزیت با انقباض کم در حفرات کلاس II مولرهای شیری

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چکیده

مقدمه: در ترمیم‌های زیبایی مستقیم، میکرولیکیج ناشی از انقباض پلیمریزاسیون، هنوز چالش برانگیز است. استراتژی‌هایی از قبیل حداکثرسازی مقدار فیلرهای غیر آلی از پیش پلیمریزه شده و ماتریکس سایلوران متفاوت، برای غلبه بر آن ارائه شد. هدف این مطالعه آزمایشگاهی مقایسه میکرولیکیج یک نوع کامپوزیت رزین متاکریلات بیس با انقباض کم (Clear fil AP-X) و یک نوع کامپوزیت رزین سایلوران بیس (Filtek P90) در حفرات کلاس II روی دندان های مولر شیری است.

مواد و روش ها: آماده سازی حفرات کلاسیک slot کلاس II روی ۶۰ دندان انسانی مولر شیری انجام شد. نمونه ها به صورت تصادفی به دو گروه تقسیم شدند. برای ترمیم حفره در گروه I : رزین کامپوزیت متاکریلات بیس و در گروه II : رزین کامپوزیت سایلوران بیس استفاده شد. نمونه ها ترموسایکل شده و ۲۴ ساعت در رنگ فوشین بازی ۲٪ غوطه‌ور شدند. مارجین‌های ژنژیوالی در مقاطع طولی و در بزرگنمایی ۱۰ × مشاهده شدند. براساس میزان نفوذ رنگ، امتیاز داده شد. آنالیز آماری با Mann-Whitney U-testدر نرم افزار SPSS 19 انجام شد.

یافته ها: در هر دو گروه، در اکثریت نمونه‌ها امتیاز نفوذ رنگ، صفر بود. مقایسه بین لیکیج مارژین ژنژیوال دو گروه تفاوت معنی دار نداشت.

نتیجه گیری: هر دو ماده بدون ارتباط با نوع، میکرولیکیج داشتند. با توجه به میکرولیکیج قابل مقایسه رزین کامپوزیت سایلوران بیس (Filtek P90)و متاکریلات بیس با انقباض کم (Clear fil AP-X) در حفرات کلاس II مولرهای شیری، به نظر میرسد کارایی کلینیکی هر دو ماده در ترمیم حفرات مذکور مشابه باشد.

واژگان کلیدی: رزین‌های سایلوران، متاکریلات‌ها، رزین کامپوزیت

Introduction

In recent decades, the tendency to use esthetic restoration materials in comparison to the traditional amalgams has been increased. [1, 2] The term "composite resin" refers to multiphase materials that have three main components including resin matrixes, filler particles and silane coupling agents. The most common resin matrixes are bisphenol A-glycidyl methacrylate and urethane dimethacrylate. [1, 3] Most of the routinely used composites undergoa 2.4-2.8% polymerization shrinkage. Some manufacturers have reduced the shrinkage range of 1.4-1.7% by adding higher filler loaded resins and used the term “low-shrinkage” for this type of composite resin materials. Nevertheless, others have altered the resin matrix with the help of silorane technology and claimed that it shows very low shrinkage. In this regard, 0.9% of this shrinkage results in decreased stress on the interface, and it is independent of increased filler loading. [1, 4] Monomers of the uncured methacrylate-based composites have intermolecular van der Waals force. By curing, these monomers form polymer networks with covalent intramolecular bonds. [5] The creation of these strains

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results in "polymerization shrinkage"; therefore, volume reduction is an inherent trait. [5, 6] One of the most common complications of shrinkage is microleakage that may be accompanied by postoperative sensitivity, staining, and recurrent caries. [1] Shrinkage determinants consist of the C-factor, material placement technique, particle size and volume of filler. [1] Numerous methods are recommended to decrease the shrinkage through technical approaches (e.g. incremental placement technique for reducing the C-factor, applying a first low-intensity light-curing exposure, using a low-elastic modulus liner, and modification in resin structure). Modification in resin structure includes maximizing the amount of inorganic filler with prepolymerized filler and low-shrinkage composites. [3, 7, 8]

The silorane-based resin composites have high filler content by volume with a compound of fine quartz particles and yttrium fluoride, driven from the fusion of siloxane backbone and four cycloaliphatic oxiranes. [6, 9, 10] Polymerization through cationic photoinitiation, cleavage, and opening of the oxiranes ring attains space and reduces the shrinkage .[1] In addition, silorane has traits such as hydrophobicity and biocompatibility. [1, 7] They display lower water sorption and solubility, lower compressive strength and microhardness, a lower degree of conversion and polymerization depth, greater flexural strength and fracture toughness, lower adhesion potential of oral streptococci, and comparable adhesion potential of Candida albicans, compared to methacrylate-based resin composites. [10] The Filtek P90 composite resin is generated from this type. [2]

Therefore, the aim of this experimental study was to compare the microleakage of the low-shrinkage methacrylate-based (Clearfil AP-X) and silorane-based (Filtek P90) composite resins in class II cavities in primary molar teeth.

Materials & Methods

Permission to perform this research was received from the Ministries of Health and Education. The ethical approval was obtained from the Research Ethics Committee and Faculty of Community Dentistry, School of Dentistry, Qazvin University of Medical Sciences, Qazvin, Iran. The study was registered under the number of IR.QUMS.REC.1394.772.

a. Sample Selection: In the present experimental study, 60 extracted human primary second molars were selected. The inclusion criterion was a sound tooth without any caries, cracks, hypoplastic defects or previous restorations. All of the specimens were hand-scaled and cleaned from calculus and debris. Then, they were examined under the direct light of the dentistry unit. The teeth were soaked in 0.5% chloramine T at 4°C for 7-10 days and stored in a normal saline solution at room temperature.

b. Cavity preparation: At the second step, the teeth were mounted in self-cured acrylic resin blocks. Class II slot cavity was prepared using the air/water-cooled high-speed handpiece (Kavo 636CP, Germany) and 008 fissure diamond bur (Jota, Switzerland). The new bur was utilized after the preparation of five teeth. The buccolingual width of the cavity was the same as 2/3 intercuspal distance. The cervical margin was located at 1 mm coronal to the cementoenamel junction, and the axial depth of the cavity was 1.5 mm in the gingival surface. The dimension of the preparation was verified using a Hu-Friedy probe (GF-W, USA).

c. Restorative procedure: Following the preparation, the mounted samples were saved in a normal saline solution until the restoration time. The teeth were randomly assigned into two groups of 30 cases, and then restored. The utilized materials in the present study are presented in Table 1.

Group I (n=30)

A primer (Clearfil SE Primer, Kuraray Medical, Tokyo, Japan) was applied in all the cavity surfaces for 20 sec, and then gently air-dried. After the application of the bonding agent (Clearfil SE Bond, Kuraray Medical, Tokyo, Japan) in the next stage, it was gently dried, and then light-cured (Guilin Woodpecker Medical Instrument Co., China) for 10 sec. The Clearfil AP-X A3 shade composite resin (Kuraray Medical, Tokyo, Japan) was placed using an oblique incremental technique in a layer thickness of 2 mm and cured using LED curing unit at a power density of 1,000 mW/cm^2 for 40 sec in a soft-start mode. Group II (n=30)

The self-etch primer (P90 self-etch primer adhesive system, 3M ESPE, Dental Product, ST Paul, USA) was utilized as per the manufacturer's instructions, by a micro brush for 15 sec, then gently air-dried and light-cured for 10 sec. The P90 bond (3M ESPE, Dental Product, ST Paul, USA) was applied, air-dried, and light-cured for 10 sec. The Filtek P90 silorane-based A3 shade composite resin (3M ESPE, Dental Product, ST Paul, USA) was placed using the oblique incremental technique with 2-mm thickness for each layer and light-cured in a soft-start mode for 40 sec.

Table 1. Composition of the applied materials and their manufacturers

Material	Composition	Manufacturer
Silorane system adhesive	**Primer:** Phosphorylated methacrylates, Vitrebond copolymer, Bis‑GMA, HEMA, water, ethanol, silanetreated silica filler, initiators, stabilizers **Bond:** Hydrophobic dimethacrylate, phosphorylated methacrylates, TEGDMA, silane‑treated silica filler, initiators, stabilizers	3M ESPE, Dental Product, ST Paul, USA
Filtek P90 composite resin	**Resin matrix:** 3,4‑epoxycyclohexylethylcyclopolymethylsiloxane, Bis‑3,4‑epoxycyclohexylethylphenylmethyl silane **Filler:** Silanized quartz, yttrium fluoride, 76.5 wt	3M ESPE, Dental Product, ST Paul, USA
Clearfil SE Bond	**Primer:** MDP, HEMA, dimethacrylate monomer, water, catalyst **Bond:** MDP, HEMA, dimethacrylate monomer, micro filler, catalyst	Kuraray Medical, Tokyo, Japan
Clearfil AP-X Composite resin	**Resin matrix:** Bis-GMA, TEGDMA, Catalysts, Accelerators, Photo initiator **Filler:** Barium glass filler, Silica filler, Colloidal silica; 85.5% wt	Kuraray Medical, Tokyo, Japan

Bis-GMA: Bisphenol A-glycidyl methacrylate HEMA: Hydroxyethylmethacrylate
TEGDMA: Triethyleneglycol dimethacrylate MDP: 10-Methacryloyloxydecyl dihydrogen phosphate

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d. Thermocycling and microleakage testing: After the restoration, the excess composite resin was eliminated; subsequently, finishing and polishing were carried out using the Sof-Lex discs (3M ESPE, Dental Product, ST Paul, USA). Afterward, the teeth were subjected to thermal cycling at 5-55°C, for 1,000 cycles with a dwell period of 30 sec. Two layers of nail-polish covered the entire tooth surface, except for 1 mm around the restoration margins.

The teeth were soaked in 2% basic fuchsine dye at 37°C for 24 h. After dye penetration, they were rinsed in tap water, and then sectioned longitudinally in the mesiodistal direction through the central fissure employing a diamond disc on a cutting machine (Mecatome, T201A, PRESI, France) under continuous irrigation water.

The sections were observed at the gingival margins with a stereomicroscope (MOTIC-SMZ-143-China) under 10×magnification to estimate the amount of microleakage. Then, microleakage scoring was measured and the obtained scores were named upon the amount of dye penetration (Table 2). The collected data were analyzed using SPSS 19.0. P-value < 0.05 was statistically considered significant.

Table 2. Dye penetration scoring criteria

Score	Criteria
0	No dye penetration
1	Dye penetration <1/3 rd. of the gingival depth
2	Dye penetration 1/3 rd.<x<2/3rd of the gingival depth
3	Dye penetration ≥2/3rd of the gingival depth

Results

Based on the Kolmogorov-Smirnov two-sample test, the distribution of data was nonparametric. The scores were evaluated using descriptive statistics, and the groups' dye penetration scores were compared using Mann-Whitney U test to identify any significant difference. Descriptive statistics of the dye penetration scores and result of inter-group comparison are shown in table 3. In both groups, the majority of the samples had a dye penetration score of 0 (group I=73.3%, group II=60%). However, the minority of the samples in group I (6.7%) obtained the scores of 2 and 3. Nonetheless, score 3 was not observed in any samples of group II (0.0%). There was no significant difference between two groups in terms of microleakage score (P=0.395).

Table 3. Distribution of dye penetration scores and mean rank via Mann-Whitney U test

Groups	n (%)	Dye penetration score 0 (%)	1(%)	2(%)	3(%)	Mean Rank	P value
I(Clearfil)	30(100%)	22(73.3%)	4(13.3%)	2(6.7%)	2(6.7%)	28.90	0.395
II(Filtek P90)	30(100%)	18(60%)	8(26.7%)	4(13.3%)	0(0.0%)	32.10	

Discussion

In the present experimental study, the microleakage of two types of low-shrinkage composite resins including silorane-based and methacrylate-based was compared in terms of class II cavities in primary molars. The current study compared the microleakage of a low-shrinkage high-filled microhybride methacrylate-based composite resin (Clearfil AP-X) with that of a low-shrinkage high-filled silorane-based composite resin (Filtek P90). They were different in matrix, volume, weight of fillers, and polymerization mechanisms. To eliminate the effect of adhesive as a confounder for both groups, the two-step self-etch adhesive system which was matched with composite manufacturer was used.

Our results revealed that both studied composite resins were indicative of microleakage at tooth-restoration interface, which could be due to the polymerization shrinkage of these materials. The majority of the samples showed a dye penetration score of 0 in both composite resins (group I [Clearfil]=73.3% and group II [Filtek P90]=60%) and the comparison of gingival marginal microleakage between two groups revealed no significant difference (P=0.395; Table 3).

The reduced polymerization shrinkage of the silorane-based composite resins which are claimed to decrease the microleakage is conflicted in the literature. In line with the results of the present study, some studies have shown no significant difference between the scores of microleakage and silorane-based and methacrylate-based composite resins. [8, 11-14]

Fahmy et al. evaluated the gingival microleakage in class II cavities in primary molars restored by the Filtek P90 (siloran-based) or Filtek supreme XT (nanohybride methacrylate-based) composite resins. Although their study design was different from that of the present research, they reported that both materials represented the best marginal seal in accordance with the dye penetration scores .[14] However, the findings of the current study are disagreement with those of other studies. Palin et al. reported that the microleakage of the silorane-based composite material was lower than that of methacrylate-based composite. [15] Additionally, Bagis reported that silorane-based material had no marginal leakage. [16] The cause of these differences may be explained by several factors. Some of these factors include evaluation of permanent teeth which are different in structural characteristics with primary teeth, mesial-occlusal-distal cavity design with different C-factors, utilized etch and rinse adhesive system for methacrylate-based composite and application of different thermocycling methods.

Al-Boni et al., Joseph et al. and Casamassimo et al. compared the silorane- and methacrylate-based composite resins using classes I and II cavity restoration of permanent teeth. They reported that siloranes could display better results in gingival microleakage. [17-19]

It is noteworthy that in the primary teeth, the thickness of enamel and dentin is thinner, especially in the cementoenamel junction area where the enamel rods are oriented cervically. Dentinal quality of the primary teeth for bonding is weaker than that of the permanent teeth due to the wild dentinal tubules. Therefore, bonding is more challenging in the primary teeth, especially in class II cavity preparation, where gingival seat is close to cervical constriction of the tooth. [20]

In recent decades, the tendency toward using esthetic restoration materials (e.g., resin composites) has been increased. However, microleakage remains one of the most common problems of clinical failure, especially at the margins of the proximal box of class II cavities. [1, 2, 11] The microleakage may be caused by the poor fitting of restorative material with cavity walls, volume variation due to polymerization shrinkage, oral thermal variations, and mechanical fatigue through repetitive masticatory loading. [21, 22] Evaluation of microleakage is the most traditional method of observing the sealing efficacy of the restorative material. [12]

Current methods to evaluate microleakage involve direct visual examination, microscopic examination, scanning electron microscopic examination, air pressure, dye penetration, use of chemical and radioactive isotope tracer, neutron activation analysis, electrochemical methodologies, measuring bacteria

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penetration, artificial caries method and three-dimensional image analysis. Dye penetration is the most frequently used method and has the benefits of simple and easy manipulation. It provides easy analysis of quantitative and comparable results with no need for costly instrumentation. Nonetheless, there is no gold standard for this method. However, this method has also some limitations, such as the subjectivity of reading and high diffusibility of dyes due to their low molecular weight. [11, 12, 23] Consequently, better results in a clinical situation may be expected. Thermocycling is a universally accepted method used in microleakage studies to reproduce the effects of oral thermal changes in materials. [11]

Based on our findings, polymerization shrinkage is not a unique determinant on the extent of microleakage. However, further clinical research is needed to confirm these findings.

Conclusion

- Both of the restorative materials, irrespective of their type had microleakage.
- Microleakage in class II cavities in the primary molars, restored with silorane-based composite resin (Filtek P90) is similar to low-shrinkage methacrylate-based composite resin (Clearfil).

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Conflict of Interest: We declare no conflict of interest.

Authors Contributions

The study was designed by Sara Maleki Kambakhsh. Sara Maleki Kambakhsh and Shima Nourmohammadi defined the conceptual content of the research. The study data were collected by Shima Nourmohammadi. Statistical analysis and interpretation of data were accomplished by Saber Babazadeh and Fatemeh Pachenari. Preparation of manuscript was performed by Fatemeh Pachenari and its editing and revision was done by Sara Maleki Kambakhsh. Study supervision was performed by Sara Maleki Kambakhsh.

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