

*Original article*

# The Influence of Composite Resin Type and Light Curing Source on the Microleakage of Composite Restorations

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## SUMMARY

The aim of this study was to evaluate the influence of composite resin type and light curing source on the microleakage of composite restorations.

The material consisted of 48 Class V cavities prepared on 24 extracted human premolars. The cavities were divided into two groups (n = 24), depending on the applied composite resin (flowable Filtek Ultimate vs universal Valux Plus). The division into two subgroups (n = 12) was dependent on the used light curing source (halogen ESPE Elipar Highlight vs LED Twinlex Blue Lex). The evaluation of composite restorations microleakage was performed using the dye penetration method with 1% methylene blue solution. The dye penetration was assessed after the longitudinal cut of the teeth. It was ranked according to the scale of 0-4.

The highest microleakage score was in the group with flowable composite and halogen light ( $2.92 \pm 1.16$ ), and the lowest in the group with universal composite and LED light ( $0.75 \pm 1.36$ ). Mann-Whitney test showed that there was a statistically significant difference in the composite restorations microleakage between the following groups: flowable/halogen vs universal/halogen, flowable/LED vs universal/LED and flowable/halogen vs universal/LED ( $p < 0.05$ ).

It can be concluded that the influence of composite resin type on composite restorations microleakage is higher than of the light curing source.

**Key words:** composite resin, light curing source, composite restorations microleakage

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## INTRODUCTION

Although composite resins are constantly improving, their polymerization contraction is still a major concern in restorative dentistry (1). The polymerization contraction occurs due to the rearrangement of monomers into polymer chains during the polymerization reaction, which reduces the initial volume of the fillings (2). One of the consequences of the polymerization contraction is the microleakage of composite restorations (3).

Microleakage is defined as the clinically invisible pass of bacteria and their products, fluids, molecules, or ions from the oral cavity along the gaps present in the tooth restoration interface (4). As this phenomenon results in many consequences such as marginal staining of restorations, secondary caries, and pulp diseases, it is important to examine the factors that can lead to it (5).

There are many factors that can influence the composite polymerization contraction, among which a type of composite resin and a light curing source are very important (6). Composite resins with lower filler content result in higher polymerization contraction (7). Also, a type of resin in organic matrix influences the polymerization contraction (8). It was noted that composite materials with a lower proportion of Bis-GMA and higher of TEGDMA resins are more prone to shrinkage (9). The shrinkage of composite resins ranges from less than 1% up to 6%, depending on the type (10).

The two most commonly used light curing sources are halogen lights and light-emitting diodes (LED) (11). Halogen curing lights usually operate at light intensities of 400–800 mW/cm<sup>2</sup> and polymerize composite restorations within 40 s (12). On the other side, light-emitting diodes (LED) produce light of greater intensity with reduced curing time and without the thermal irritation of the tooth pulp, so today they are very popular in restorative dentistry (13, 14).

The aim of this study was to evaluate the influence of composite resin type and light curing source on the microleakage of composite restorations.

The working hypothesis was that there is a statistically significant difference between the influence of composite resin type and light curing source on the microleakage of composite restorations.

## MATERIAL AND METHODS

The study was conducted at the Clinic of Dentistry in Niš, at the Department of Restorative Dentistry and Endodontics. The material consisted of 48 Class V

cavities prepared on 24 sound human premolars that were extracted for orthodontic reasons. The cleaning of teeth was done with polishing brushes and abrasive paste. After that, the teeth were stored in formalin until the start of research.

The Class V cavities were prepared on the buccal and oral surfaces of teeth with a round diamond drill (Mesinger, Germany), in diameter 107-126 µm, using a high-speed handpiece with a water-air cooling. A drill was replaced with a new one after every sixth preparation. The cavities were located 0.5 mm above the cemento-enamel junction and their dimensions were: 3.5 mm in width, 2 mm in height and 1.5 mm in depth. The dimensions of the cavities were checked with a digital caliper (Asimeto 307-06-1, Canada), with an accuracy of 0.01 mm.

The enamel edges were slanted for 0.5-1 mm with a fine flame diamond drill (Mesinger, Germany), 40 µm in diameter, using low-speed rotations. Thirty-five percent phosphoric acid, Scotchbond Etchant (3M ESPE Dental Products, St. Paul, MN, USA), was used for etching the edges of the enamel and the entire surface of the cavity for 15 s, followed by the 10 s rinsing and drying by cotton pellets. The adhesive Adper Single Bond 2 (3M ESPE Dental Products, St. Paul, MN, USA) was applied by a cotton pellet, mildly air-dried (5 s), and cured for 20 s with the appropriate light source.

Forty-eight teeth cavities were randomly divided into two groups (n = 24), depending on the applied composite resin. The first group was restored with flowable composite resin Filtek Ultimate (3M ESPE Dental Products, St. Paul, MN, USA), and the second group with universal composite resin Valux Plus (3M ESPE Dental Products, St. Paul, MN, USA). The composites were applied in one layer into the Class V cavities.

The division into two subgroups (n = 12) was performed depending on the used light curing source. The first subgroup was cured using halogen light ESPE Elipar Highlight (3M ESPE Dental Products, St. Paul, MN, USA), and the second subgroup with LED light Twinlex Blue Lex (Monitex, Taiwan). The composite restorations were cured at a distance of 2 mm, for 40 s. The final processing of restorations was done with Sof-Lex discs and rubbers (3M ESPE Dental Products, St. Paul, MN, USA). There were a total of four experimental groups after the application of two types of composite resin and light curing source (Table 1).

The isolation of teeth was performed with two layers of nail varnish, except for the composite restorations and 1 mm around them. The root apices were sealed with sticky wax, to prevent apical microleakage. The

evaluation of microleakage was carried out using the dye penetration method. The teeth were immersed in 1% methylene blue solution for 24 h. After that, the teeth were rinsed under running water for 60 s and they were dried at room temperature.

The teeth were sectioned longitudinally in the buccolingual direction through the center of the restoration with a diamond disc, 6 mm in diameter, mounted on a technical micromotor, with a water cooling. The evaluation of dye penetration into the enamel and dentin was performed using a magnifying glass with 8× magnification. The scale of 0 to 4 was used to rank the degree of dye penetration, according to the method by Parolia et al. (15):

0 = no dye penetration;

1 = dye penetration within 1/3 of the cavity wall;

2 = dye penetration within 2/3 of the cavity wall;

3 = dye penetration along the last 1/3 of the cavity wall up to the axial wall;

4 = dye penetration along the axial wall.

Statistical analysis was performed using the software package SPSS version 16.0 (SPSS Inc., Chicago, Illinois, USA). Data were presented as the mean value and standard deviation. The normality of data was

tested by Shapiro-Wilk test. Kruskal-Wallis and Mann-Whitney U tests were used for intergroup comparison of the composite restorations microleakage.

## RESULTS

The mean value and standard deviation of the composite restorations microleakage score for experimental groups are presented in Table 1. The highest microleakage score was in the first group with flowable composite and halogen light ( $2.92 \pm 1.16$ ), and the lowest in the fourth group with universal composite and LED light ( $0.75 \pm 1.36$ ). Shapiro-Wilk test showed normal distribution of data in all groups.

Kruskal-Wallis test showed that there was a statistically significant difference in the microleakage of composite restorations between tested groups ( $p < 0.05$ ). Mann-Whitney U test showed that statistically significant difference in the microleakage was between the following groups: I vs III, I vs IV and II vs IV ( $p < 0.05$ ). The statistical difference between other groups was not significant (I vs II, II vs III and III vs IV) ( $p > 0.05$ ) (Table 2).

*Table 1. The mean value and standard deviation of the microleakage score for experimental groups*

Group	Composite resin	Light curing source	Mean $\pm$ SD
I	Flowable composite	Halogen light ESPE Elipar	<b>2.92 <math>\pm</math> 1.16</b>
	resin Filtek Ultimate	Highlight	
II	Flowable composite	LED light Twinlex Blue	2.08 $\pm$ 1.73
	resin Filtek Ultimate	Lex	
III	Universal composite	Halogen light ESPE Elipar	1.17 $\pm$ 1.27
	resin Valux Plus	Highlight	
IV	Universal composite	LED light Twinlex Blue	<b>0.75 <math>\pm</math> 1.36</b>
	resin Valux Plus	Lex	

Table 2. The intergroup comparison of the composite restorations microleakage

Groups	Kruskal-Wallis test	Mann-Whitney U test
	H value	U value
I vs II		53.5
I vs III		23*
I vs IV		17*
II vs III		46.5
II vs IV	12.76*	36.5*
III vs IV		51

\*p < 0.05 - statistically significant difference;

I - flowable composite/halogen light;

II - flowable composite/LED light;

III - universal composite/halogen light;

IV - universal composite/LED light

## DISCUSSION

Composite resins represent the most commonly used restorative material today, due to their good esthetic, physical and mechanical properties (14, 16). However, despite numerous advantages, polymerization contraction, and consequently microleakage have still remained as a drawback (15). Therefore, microleakage can be used as a measure for the evaluation of clinical performance of composite restorations (17).

There are different techniques for in vitro evaluation of composite restorations microleakage, among which dye penetration method is the most widely applied. As this method is practical, simple and precise, we used it in our study (15). The most commonly used penetrating dyes are basic fuchsin, methylene blue, and silver nitrate (5, 18). Methylene blue was selected as the dye since it has high penetrability and detectability. Its contrast enables good visualization (17). How methylene blue microleakage of composite restorations was evident, we used a magnifying glass only to confirm its degree and the use of light microscopy was not necessary.

In our study, the microleakage of composite restorations was evaluated in Class V cavities because Class

V lesions are minimal and it is easier to standardize the preparation than in Class II cavities. Also, the Class V cavities have an unfavorable C-factor, resulting in a greater contraction in the adhesive bonded material and thus enable better evaluation of that their property (19).

We evaluated a microleakage of two composite resin types: flowable composite Filtek Ultimate and universal composite Valux Plus. The flowable Filtek Ultimate is a new, low-viscous nanocomposite characterized by a lower shrinkage, better esthetics and easier application than its predecessors. Universal Valux Plus is a hybrid, methacrylate-based composite characterized by a high strength and high wear resistance. These two composites were applied after the previous application of Adper Single Bond 2 adhesive (two-step, etch and rinse adhesive system). Adper Single Bond 2 was evaluated in our previous studies where it exhibited better marginal adaptation of composite restorations than other examined adhesive (Adper Easy One, one-step, self-etch adhesive system) (20, 21). This prompted us to use this adhesive in combination with the composite materials from the same manufacturer (3M) in order to see how much the influence of light curing source on the composite restorations microleakage is.

According to the scale of 0-4 (15), the highest microleakage score was in the group with flowable composite resin Filtek Ultimate and halogen light ESPE Elipar Highlight. This score can be explained by the fact that flowable Filtek Ultimate has less inorganic fillers (46% by volume) in its structure than universal composite Valux Plus (64% by volume), resulting in higher polymerization contraction, and thus in microleakage. A higher microleakage of the composite restorations after the application of the halogen light ESPE Elipar Highlight was probably a consequence of its lower intensity (700 mW/cm<sup>2</sup>), in comparison with the LED light Twinlex Blue Lex (1800 mW/cm<sup>2</sup>), that resulted in a poorer polymerization of composite materials. The scale for estimation dye penetration is individual, how there were researchers who applied the scale of 0-2 (17), 0-3 (16, 19, 22) and 0-5 (12).

After analyzing the results, the working hypothesis was confirmed. The influence of composite resin type on microleakage was higher, and after intergroup comparison a statistically significant difference was noted between groups where the composite resin was different and the light curing source was the same (I vs III and II vs IV). A significant difference was also noted in a comparison of the flowable composite group cured with the halogen light and the universal composite group cured with the LED light (I vs IV). This significant difference is most likely due to the already mentioned differences in the structure of applied composite resins and different intensities of light curing sources.

There was no statistically significant difference when the groups with the same composite resin and a different light curing source were compared (I vs II and III vs IV). Also, there was no significant difference between the flowable composite group cured with the LED light and universal composite group cured with halogen

light (II vs III). This suggests a similar clinical effect of these two groups (flowable composite/LED light and universal composite/halogen light).

Our results are consistent with the study by Yilmaz et al. where a statistically significant difference was observed between the applied composite resins (two dimethacrylate-based, Aelite Aesthetic Enamel and InTen-S and one silorane-based composite, Filtek Silorane), but not between the applied light curing sources (LED light, Hilux Led-max and Quartz-tungsten-halogen light, Smart-Lite) (12). A statistically significant difference between the different types of composite materials was also observed in the study by Parolia et al. (Silorane-based composite, Filtek P 90, dimethacrylate-based, Solare P and light-cure glass ionomer cement, GC Fuji II LC) (15). Regarding the influence of the light curing source on the composite restorations microleakage, there was no observed significant difference between the different modes of the same light source (ESPE Elipar Highlight, standard and soft start modes), which was also confirmed in our previous studies (20, 23).

## CONCLUSION

Despite the limitations of the in vitro studies, it can be concluded:

1. The influence of composite resin type on the microleakage of composite restorations was higher than of the light curing source;
2. The highest microleakage of the composite restorations was observed in restorations that were restored with flowable composite and cured with halogen light;
3. The lowest microleakage was observed in universal composite restorations cured with LED light.

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## Uticaj vrste kompozitne smole i svetlosnog izvora na mikropropuštanje kompozitnih restauracija

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### SAŽETAK

Cilj ove studije bio je da se ispita uticaj vrste kompozitne smole i svetlosnog izvora na polimerizaciju na mikropropuštanje kompozitnih restauracija.

Materijal je činilo 48 kaviteta V klase, koji su preparisani na 24 ekstrahirana ljudska pretkutnjaka. Kaviteti su podeljeni u dve grupe (n = 24), zavisno od primenjene kompozitne smole (tečna Filtek Ultimate naspram univerzalne Valux Plus). Podela na dve podgrupe (n = 12) zavisila je od upotrebljenog svetlosnog izvora za polimerizaciju (halogeni ESPE Elipar Highlight naspram LED Twinlex Blue Lex). Ispitivanje mikropropuštanja kompozitnih restauracija je sprovedeno metodom prodora boje sa 1%-tnim rastvorom metilenskog plava. Prodor boje je procenjen nakon uzdužnog presecanja zuba. Rangiran je prema skali od 0-4.

Najveći stepen mikropropuštanja je bio u grupi sa tečnim kompozitom i halogenim svetlom ( $2,92 \pm 1,16$ ), a najmanji u grupi sa univerzalnim kompozitom i LED svetlom ( $0,75 \pm 1,36$ ). Mann-Whitney test je pokazao da je postojala statistički značajna razlika u mikropropuštanju kompozitnih restauracija sledećih grupa: tečni/halogeno naspram univerzalni/halogeno, tečni/LED naspram univerzalni/LED i tečni/halogeno naspram univerzalni/LED ( $p < 0,05$ ).

Može se zaključiti da je uticaj vrste kompozitne smole na mikropropuštanje kompozitnih restauracija veći od uticaja svetlosnog izvora za polimerizaciju.

**Ključne reči:** kompozitna smola, svetlosni izvor za polimerizaciju, mikropropuštanje kompozitnih restauracija