Evaluation of microleakage and the degree of conversion of three composite resins polymerized at different power densities

Avaliação da microinfiltração e do grau de conversão de três resinas compostas polimerizadas em diferentes densidades de potência

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ABSTRACT

Objectives: This study aims to evaluate the degree of conversion (DC) and microlekage scores of three different composite resins polymerized with a LED curing device in standard and extra-power mode. **Material and Methods:** One bulk-fill (Tetric EvoCeram Bulk-Fill – TECBF) and two conventional composite materials (Clearfil Majesty Posterior – CMP and Tetric EvoCeram – TEC) were evaluated. A total of 30 specimens were prepared for six groups (N = 5). These groups were polymerized with a LED curing device as follows: TECBF-6: 3200mW/cm² for six seconds, TECBF-20: 1000mW/cm² for 20 seconds, CMP-6: 3200mW/cm² for six seconds, CMP-20: 1000mW/cm² for 20 seconds, TEC-6: 3200mW/cm² for six seconds, TEC - 20: 1000 mW/cm² for 20 seconds. After 24 hours of water storage, DC was measured by Raman spectroscopy. Microleakage scores of the six groups were bonded to various adhesive systems (Clearfil SE Bond or Adhese Bond Universal) were also evaluated at Class II box cavities (N = 10). **Results:** While the highest DC was found at the top (TECBF-20= 79.92% and TECBF-6= 79.02%) and bottom surfaces (TECBF-20 = 68.94% and TECBF-6= 71.04%) for TECBF groups, TEC groups (TEC-20top = 59.06%, TEC-6top=49.66%, TEC-20bottom = 43.72% and TEC-6bottom= 40.68%) showed the lowest DC for the both surfaces (p < 0.05). Polymerization of materials in standard or extra-power mode was similar to DC (p > 0.05). Microleakage scores were found to be similar (p > 0.05). **Conclusion:** According to the results of the study, different power densities of LED curing light did not affect the DC of composite resins and microleakage values of restorations at small Class II cavities.

KEYWORDS

Bulk-fill composite; degree of conversion; LED curing device; microleakage; Raman spectroscopy.

RESUMO

Objetivo: este estudo tem como objetivo avaliar os graus de conversão (DC) e microinfiltração de três diferentes resinas compostas polimerizáveis com um dispositivo de luz por LED nos modos padrão e no modo de alta-potência. **Material e métodos:** uma resina bulk-fill (Tetric EvoCeram Bulk-Fill - TECBF) e dois materiais resinosos convencionais (Clearfil Majesty Posterior - CMP e Tetric EvoCeram - TEC) foram avaliados. Um total de 30 espécimes foram preparados e divididos em seis grupos (N = 5). Esses grupos foram polimerizados com um dispositivo de luz de LED da seguinte forma: TECBF-6: 3200mW / cm² por seis segundos, TECBF-20: 1000mW / cm² por 20 segundos, CMP-6: 3200mW / cm² por seis segundos, CMP-20: 1000mW / cm² por 20 segundos, TEC-6: 3200mW / cm² por seis segundos, TEC - 20: 1000 mW / cm² por 20 segundos. Após 24 horas de armazenamento em água, a DC foi medida por espectroscopia Raman. Os escores de microinfiltração dos seis grupos dos vários sistemas adesivos (Clearfil SE Bond ou Adhese Bond Universal) também foram avaliados nas cavidades Classe II (N = 10). **Resultados:** embora a maior CD tenha sido encontrada nas partes superior (TECBF-20 = 79,92% e TECBF-6 = 79,02%) e inferiores (TECBF-20 = 68,94% e TEC-6bottom = 71,04%) para grupos TECBF, os grupos TEC (TEC-20top = 59,06%, TEC-6top = 49,66%, TEC-20bottom = 43,72% e TEC-6bottom = 40,68%) apresentaram as menores CD para as ambas as partes (p < 0,05). A polimerização de materiais no modo padrão ou alta-potência foi semelhante à DC (p > 0,05). Os escores de microinfiltração foram semelhantes (p > 0,05). **Conclusão:** de acordo com os resultados do estudo, diferentes densidades de potência da luz de LED não afetaram as CD das resinas compostas e os valores de microinfiltração das restaurações em pequenas cavidades da Classe II.

PALAVRAS-CHAVE

Resina de inserção em bloco; Grau de conversão; Dispositivo de polimerização por LED; Microinfiltração; Espectroscopia Raman.

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INTRODUCTION

Composite resin materials have been used more often today as a restorative material, and the DC of these materials of these soft monomers to rigid polymers appears to be an important situation for clinical success [1]. DC is an important determinant of the physical, chemical and mechanical properties [2]. Adequate DC is also clinically significant for all physical properties such as hardness, elastic modulus, strength, dimensional stability, solubility, water sorption and color stability [3,4]. However, it should also be noted that there are other factors affecting the success of the restoration. DC is influenced by some factors such as filler amount, resin type, resin shade, spectrum and power of the polymerization light. [5]. Composite resin materials should be biocompatible, having good mechanical characteristics and low polymerization shrinkage. DC is an equally important consideration for any restorative material and filling technique [6]. While conventional composite resins reach a DC of approximately 50%-75% [7,8], this rate is reported to range from 50%-79% for bulk-fill composites [9, 10]. It has been reported in the literature that the DC should be at least 55% for clinical success [10,11]. Fourier Transform Infrared (FTIR) spectroscopy [12] and Raman spectroscopy [13] commonly uses spectroscopic and accurate methods to evaluate DC. In Raman spectroscopy, since the samples are not damaged, it allows multiple measurements on the same sample. In addition, samples are easier to prepare for Raman spectroscopy [14].

Marginal integrity/adaptation, polymerization shrinkage and therefore microleakage are important factors affecting the clinical success of composite restorations. DC and shrinkage stresses are directly dependent on each other. As a consequence, the reduction in DC would result in lower shrinkage and lower shrinkage stress. The volumetric shrinkage of currently used composites is between 2% and 6% [15]. The polymerization shrinkage stresses can be reduced by slowly polymerizing the composite resin material without affecting the final DC. A slower growing polymer network can delay the formation of shrinkage, resulting in reduced shrinkage forces via molecular rearrangements [16]. This leads to an increased time for the polymerization procedure. Whereas the rapid polymerization of composite resins leads to high polymerization shrinkage and offers considerable time-savings. It also leads to cuspal deflection, enamel cracks, gap formation, microleakage, secondary caries and post-operative sensitivity [17,18].

Short-time polymerization of composite resins with high-intensity LED curing devices saves considerable time and this provides an advantage both for the patient and the clinician. However, it is of interest to see how the DC of the material and the microleakage scores of the restoration will be affected after rapid polymerization.

The aim of this study was to evaluate the degree of conversion of three different composite resins polymerized with a LED light device in the standard (1000 mW/cm^2) and extra-power (3200mW/cm^2) modes. Microleakage scores of composites were also investigated in Class II box cavities after the standard and rapid polymerization procedures. The tested null hypotheses were: 1. There is no difference between microleakage scores of aproximal box cavities restored with composite resin, which are polymerized at different power densities. 2. There is no difference between the DC of composite materials that are polymerized at different power densities.

MATERIAL AND METHODS

Degree of conversion (DC)

One bulk-fill (Tetric EvoCeram Bulk-Fill - TECBF) and two conventional (Clearfil Majesty Posterior - CMP and Tetric EvoCeram - TEC) composite resin materials were evaluated in a total of six groups. For each material ten cylindrical specimens were prepared with a diameter of 8 mm and an adjustable depth using a teflon mold. The depth of the specimens was 4 mm for bulk-fill composites and 2 mm for conventional composites. The composite resin

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materials were inserted into single increments for all groups. Polyester strip bands were used before polymerizing to eliminate the oxygen inhibition layer and to obtain flat surfaces. Two different polymerization modes for each material were assigned two different subgroups (N = 5). A third-generation LED device (Valo Cordless, Ultradent, USA) was used for sample polymerization. Specimens were polymerized as follow: TECBF-6: 3200mW/cm² for six seconds, TECBF-20: 1000mW/cm² for 20 seconds, CMP-6: 3200mW/cm² for six seconds, CMP-20: 1000mW/cm² for 20 seconds, TEC-6: 3200mW/cm² for six seconds and TEC-20: 1000mW/cm² for 20 seconds. After that, the polymerized samples were stored in distilled water at a dark ambit for 24 hours before testing. For each sample two Raman spectra were obtained, one for the top surface and the other for the bottom.

Raman spectra of samples were obtained by using a computer-controlled laser Raman spectroscopy (Renishaw InVia, Renishaw plc, UK) integrated with an optical microscope with x100 magnification (NA 0.9; N Plan EPI objective; Leica, Germany). A 785 nm diode laser was used for Raman scattering effect. The exposure time was 40 seconds for each scan, and the power of the diode-laser was 8mW. Raman spectra were obtained from both polymerized (N = 5) and non-polymerized (N = 5) forms of the materials for calculating the DC of the polymerized specimens. DC was calculated by comparing the changes of polymerized and non-polymerized specimens in the 1,640 cm^{-1} band, which is the C = C reference band that represents the C = C stretching mode. For Tetric EvoCeram, Tetric EvoCeram Bulk-Fill and Clearfil Majesty Posterior the aromatic C=C band at 1,610 cm-1 was used as a reference [19]. To calculate the DC, the following equation was used: $DC = 1 - R_{polymerized}/R_{unpolymerized} \times 100$, where R = (C=C band area)/(reference band area) [20].

Microleakage and marginal adaptation

Thirty caries-free human third molars extracted for clinical reasons were selected for the study. The teeth were obtained from the oral surgery department after obtaining the patients' consent and approval of the ethics committee (Decision No: 12/10). Initially, the samples were checked with x40 magnification (OPMI Pico, Carl Zeiss Meditec, Germany) with an operating microscope to see if any developmental defects or cracks were present in the crowns of the teeth. Possible debris and residues on the teeth were removed with a scaler. The teeth were disinfected by immersion in 0.1% thymol for seven days and were kept in distilled water.

Teeth were randomly divided into six groups, and only two Class II box cavities were prepared with mesial and distal surfaces using an aerator under water cooling and diamond fissure burs (Dia-burs SF-13, Mani Co., Japan). Each cavity had a cervical limit of 1 mm above the cementoenamel junction, gingival seat thickness of 2 mm and buccolingual width of 4 mm. Marginal edges were not beveled. (Figure 1).
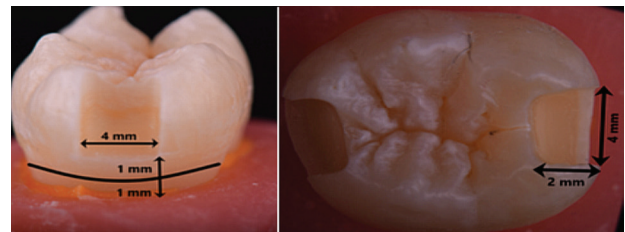

Figure 1 - Cavity parameters

All cavities were prepared by one operator and the dimensions were checked using a digital caliper (Mitutoyo, Kawasaki, Japan) and periodontal probe during and after the cavity preparation. After each of the four preparations, the bur was changed with a new one. Incorrect samples were not included in the study.

For the CMP-20 group restorations, the adhesive material (Clearfill SE Bond, Kuraray, Japan) was applied to the cavities using a disposable brush according to the manufacturer's instructions and polymerized for 10 seconds with the LED curing (Valo Cordless, Ultradent, USA) device at 1000 mW/cm² power. After that, metal matrix bands (Adapt SuperCap Matrix no 2182, Kerr-

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Hawe, Switzerland) were placed. Cavities filled 2 mm horizontal incremental technique with a posterior nano-hybrid composite resin (Clearfil Majesty Posterior, Kuraray, Japan) and each increment polymerized with the LED device at 1000mW/cm² for 20 seconds. For the CMP-6 group, each process was carried out in the same manner, while the adhesive system was polymerized for three seconds at 3200 mW/cm² and each layer was polymerized for six seconds at 3200 mW/cm².

For the TECBF-20 group, the adhesive material (Adhese Bond Universal, Ivoclar Vivadent, Liechtenstein) was applied to the cavities using a disposable brush according to the manufacturer's instructions and polymerized for ten seconds with the LED curing (Valo Cordless, Ultradent, USA) device at 1000 mW/cm² power. After that, metal matrix bands (Adapt SuperCap Matrix no 2182, Kerr-Hawe, Switzerland) were placed. Cavities were filled with a 4 mm horizontal bulk technique with a bulk-fill nanohybrid composite resin (Tetric EvoCeram Bulk-Fill, Ivoclar Vivadent, Liechtenstein) and each increment polymerized with the LED device at 1000mW/cm² for 20 seconds. For the TECBF-6 group, each process was carried out in the same manner, while the adhesive system was polymerized for three seconds at 3200 mW/cm² and each layer was polymerized for six seconds at 3200 mW/cm².

For the TEC-20 group, the adhesive material (Adhese Bond Universal, Ivoclar Vivadent, Liechtenstein) was applied to the cavities using a disposable brush according to the manufacturer's instructions and polymerized for ten seconds with the LED curing (Valo Cordless, Ultradent, USA) device at 1000 mW/cm² power. After that, metal matrix bands (Adapt SuperCap Matrix no 2182, Kerr-Hawe, Switzerland) were placed. Cavities were filled with a 2 mm horizontal incremental technique with a nanohybrid composite resin (Tetric EvoCeram, Ivoclar Vivadent, Liechtenstein) and each increment polymerized with the LED device at 1000mW/cm² for 2 seconds. For the TEC-6 group, each process was carried out in the same manner, while the adhesive system was polymerized for three seconds at 3200 mW/cm² and each

layer was polymerized for six seconds at 3200 mW/cm².

Finishing and polishing procedures to all groups were performed using an aluminum oxide finishing and polishing kit (Super Snap Rainbow Technique Kit, Shofu, Japan). Each group consisted of ten restorations (n = 10). The materials used in the study are listed in Table I.

Table I - Materials used in the study

Product name	Lot Number	Composition	Manufacturer
Clearfil SE Bond Adhesive System	000242	Primer: - 2-Hydroxyethyl methacrylate (HEMA), - proprietary acidic phosphate monomer, - 10-Methacryloyloxydecyl dihydrogen phosphate (MDP), - Hydrophilic aliphatic dimethacrylate, - dl-Camphorquinone, - Accelerators and Water. Bond: - Bisphenol A diglycidylmethacrylate (Bis-GMA), 2-Hydroxyethyl methacrylate (HEMA), - 10-Methacryloyloxydecyl dihydrogen phosphate (MDP), - Hydrophobic dimethacrylate, - N,N-diethanol-p-toluidine, - Silanated colloidal silica, - dl-Camphorquinone,	Kuraray
Adhese Bond Universal	W34093	10-Methacryloyloxydecyl dihydrogen phosphate (MDP), - 2-Hydroxyethyl methacrylate (HEMA), Bisphenol A diglycidylmethacrylate (Bis-GMA), methacrylated carboxylic acid polymer (MCAP), decanedio dimethacrylate (D3MA), Ethanol, Water, Fillers, Initiators	Ivoclar Vivadent
Tetric EvoCeram Bulk-Fill Composite (Shade IVA)	U26276	Resin Matrix: Urethane dimethacrylate (UDMA), Bisphenol A diglycidylmethacrylate (Bis-GMA), Ethoxylated bisphenol A dimethacrylate (Bis-EMA) Filler: (61% vol.) - Barium aluminum silicate glass fillers, - Ytterbium fluoride, - Isofiller (composed of cured dimethacrylates, glass filler and ytterbium fluoride), - Spherical mixed oxide filler	Ivoclar Vivadent
Clearfil Majesty Posterior Composite (Shade A2)	B20038	Resin Matrix: Bisphenol A diglycidylmethacrylate (Bis-GMA), - Triethylene glycol dimethacrylate (TEG-DMA), - Hydrophobic aromatic dimethacrylate, - dl-Camphorquinone, - Accelerators Filler: (83% vol.) - Surface treated alumina micro filler, - Silanated silica filler, - Glass ceramics	Kuraray
Tetric EvoCeram Composite (Shade A2)	U23115	Resin Matrix: - Dimethacrylates (Bis-GMA and UDMA), - initiators, - stabilizers and pigments Filler: (53%-55%) - ytterbium trifluoride, - barium glass, - mixed oxide and copolymers	Ivoclar Vivadent

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After the restoration process, the teeth were stored in distilled water for 24 hours. All the teeth were then thermocycled 10,000 times in 5-55 °C water bathes (Thermal Cycler, Esetron Smart RoboTechnologies, Turkey) with a dwell time of 15 seconds for each bath. After the thermocycle process, marginal edges of the restorations were evaluated under a stereomicroscope (S100 OPMI pico, Carl Zeiss Meditec, Germany) with x40 magnification. After that, one specimen from each group was selected randomly and impressions of the specimens were taken using a polyvinyl siloxane material (S4 Suhy, Bisico, Germany) and epoxy resin replicas were obtained. Replicas were evaluated under a Scanning Electron Microscope (JSM-5600, Jeol Ltd., Japan).

Apical foramen of the teeth were plugged with sticky wax and each tooth was covered with two coats of nail varnish as well as 1 mm from the restoration margins. Coated teeth were immersed in 1% methylene blue solution for 24 hours and then separated longitudinally in a mesiodistal direction though the middle of the restorations using a low-speed cutting device (Microcut 126, Metkon, Turkey). Longitudinally separated samples were examined using a stereomicroscope (S100 OPMI pico, Carl Zeiss Meditec, Germany) with x40 magnification and the occlusal/gingival microleakage scores of each restoration were evaluated by two calibrated investigators who blinded to groups. The microleakage evaluation criteria are shown in Table II and the detailed steps of the study design are explained in Figure 2. Data were analyzed using the SPSS 22.0 program with Kruskal-Wallis and Man-Whitney U tests.
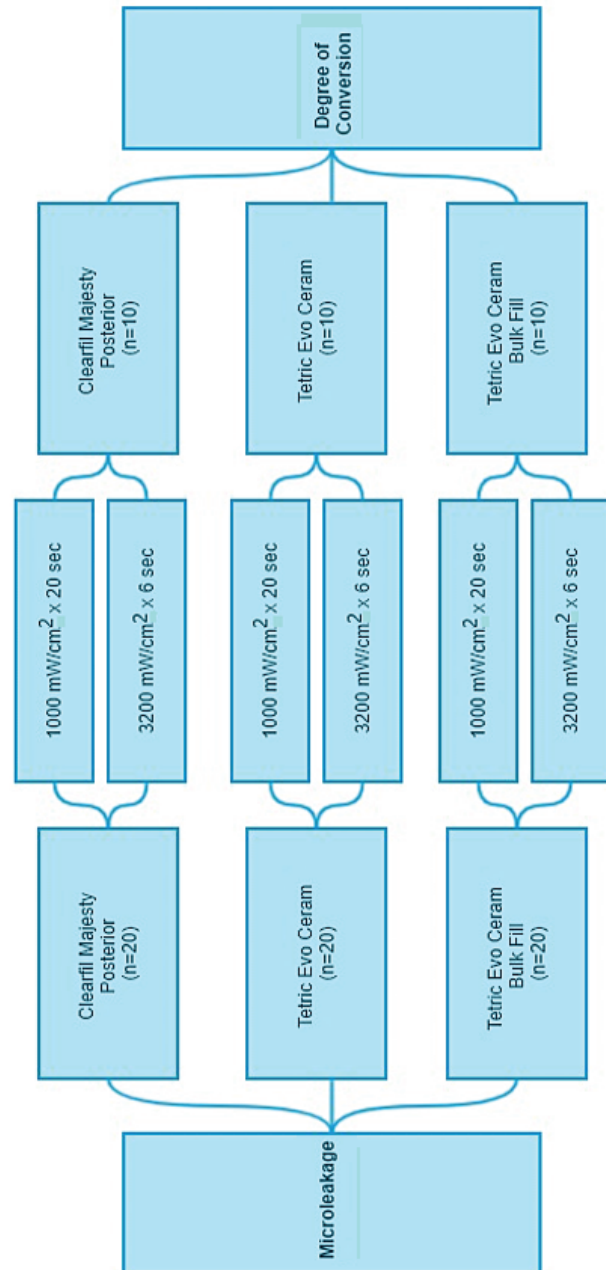

Figure 2 - Schematic view of study design.

Table II - Microleakage evaluation criteria

Microleakage scores	Occlusal microleakage description	Gingival microleakage description
0	No dye penetration	No dye penetration
1	Dye penetration for half extension	Dye penetration for half extension of the cervical wall
2	Dye penetration more than half	Dye penetration for more than half of all of the cervical wall
3	Dye penetration for the pulpal wall	Dye penetration into the pulp

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RESULTS

Degree of Conversion

Bulk-fill groups had significantly higher DC than other groups ($p < 0.05$). The mean level of polymerization degree ranged from highest to lowest TECBF-6, TECBF-20, CMP-20, CMP-6, TEC-20, TEC-6 respectively.

The same composites showed similar DC, as a result of rapid and standard polymerization ($p > 0.05$). Top surfaces of the composite specimens showed statistically higher DC values than bottom surfaces ($p < 0.05$), except the CMP-20 Group. DC results are shown in Figure 3.
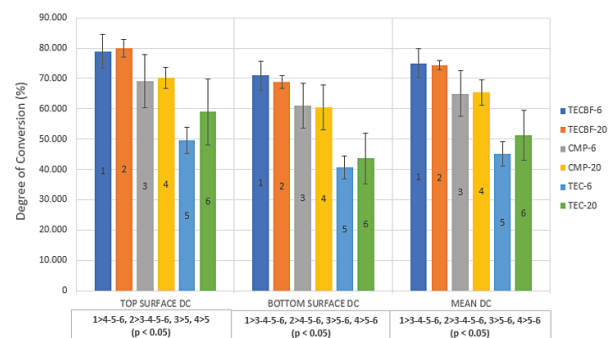

Figure 3 - Bar graphs of "Top Surface DC", "Bottom Surface DC" and "Mean DC" of the composite materials.

Marginal adaptation and microleakage scores

No marginal maladaptation was observed in any of the samples examined under the stereomicroscope. In addition, no marginal maladaptation was observed in the examination of epoxy resin replicas under SEM. Gingival microleakage scores were found to be significantly higher than occlusal microleakage scores in TECBF-6 and TEC-6 ($p < 0.05$). Microleakage values at the occlusal regions of the groups were similar, and no significant differences were found between the groups ($p > 0.05$). For gingival microleakage scores, polymerized with extra-power mode groups showed higher microleakage values and no statistically significant information was found ($p > 0.05$). The distribution of the microleakage scores of the occlusal and gingival edges are shown in Figure 4.
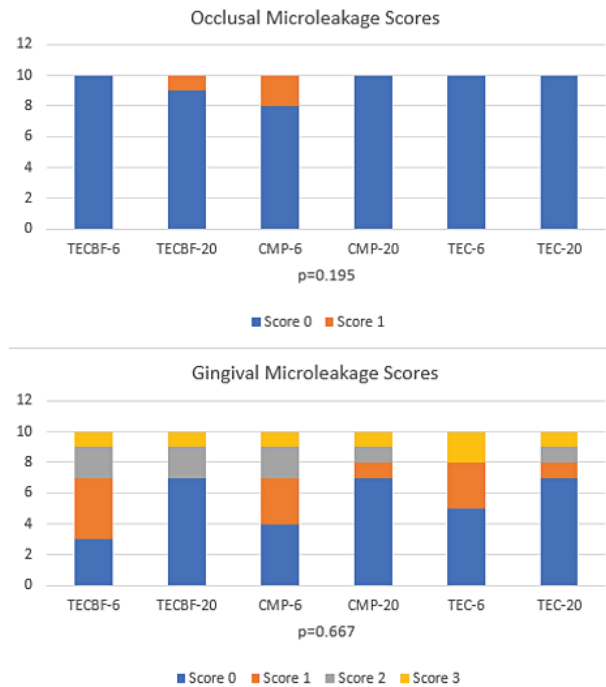

Figure 4 - Microleakage scores of the occlusal and gingival edges.

DISCUSSION

This study was performed to investigate the DC values and microleakage scores in Class 2 cavities of three composite resin material after rapid and standard polymerization procedures. The microleakage scores of all groups were found to be similar according to the findings of this study and the first null hypothesis were accepted.

The presence of marginal gap can be considered as the first sign of failure of the restoration [21]. While some studies evaluate the gap width, presence or absence of a gap is more important [22]. Evaluating the adaptation of the restoration margins with SEM has been accepted as a reliable method [23]. For this purpose, epoxy resin replica of a randomly selected specimen from each group was examined under SEM. Additionally, all specimens were examined under a stereomicroscope. If a visual discrepancy was detected after these examinations, it could be interpreted that restorations would fail in the early period, but it was observed that all

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specimens showed good marginal adaptation.

Gamarra et al. reported that marginal adaptation of the restorations is quite good when cavity margins are limited to enamel [24] and Campos et al. reported that dentin margins were more incompatible than enamel margins [25]. In this study, cavity margins were limited to enamel and the results were consistent with the studies above.

In dental composite resins, as in all polymeric materials, polymerization shrinkage that occurs during the conversion of monomers to polymers is one of the most important clinical problems encountered today [26]. As a result of polymerization shrinkage, clinical problems such as postoperative sensitivity, margin coloration, secondary caries, fractures in restorative material, loss of restoration, pulp inflammation and pulp necrosis occur due to microleakage at the tooth-restoration margin. Considering all these reasons, it can be said that microleakage is one of the most important criteria for evaluating the clinical success of restorations [27]. Polymerization shrinkage stress depends on many factors, such as the size of the cavity, the form of the cavity, the type of the substrate, the localization of the cavity margins, the restorative material used, and the placement and the polymerization technique [28]. In large restorations, it is important to reduce microleakage at the tooth/restoration interface [29]. For this reason, some studies have been conducted such as the development of adhesive systems, different light application protocols or the use of different layering methods in order to prevent microleakage [26].

According to the findings of this study, microleakage could not be prevented completely in any group. Although rapid polymerized groups showed slightly more microleakage, this was not significant. Methylene blue solution was used in many studies related to microleakage in terms of its low cost and easy preparation [30]. Methylene blue is smaller in size than bacteria. Therefore, it can show microleakage even in areas that are too small for bacteria to penetrate [31].

Placing composite resin material into the cavity in layers of 2 mm thickness allows better light transmission and therefore better polymerization of the composite resin. However, by using the layering technique, advantages such as reduction of configuration factor and cuspal deflection, and consequently reduction of bonding failures, can be achieved [28] In bulk-fill composite resins, some changes have been made to the filler content of the composite in order to increase the polymerization depth. Compared to conventional composite resins, bulk-fill composite resins have larger fillers ($> 20 \ \mu m$) and less filler-matrix contact. In this case, the light is less scattered and penetrates deeper [32]. In Tetric EvoCeram Bulk-Fill a new initiator named Ivocerin also allows polymerization of higher increments [33]. According to the literature, polymerization shrinkage of bulk-fill composites was regulated with modifications in an organic matrix [34,35]. As a result of this study, similar microleakage scores can be explained by similar polymerization shrinkage characteristics.

Kader et al. restored Class II cavities in human molar teeth by incremental (Filtek Z250) and bulk (Filtek bulk-fill) techniques and evaluated the microleakage. According to the data obtained, they showed that there is no statistically significant difference in microleakage scores, irrespective of the insertion technique [36]. According to the findings of this study polymerization of dental composite materials with standard or extra-power mode and the placement of the composite materials with incremental or bulk technique did not significantly affect the microleakage scores between the groups. Cavity size and composite volume are important parameters in terms of microleakage [37,38]. In this study, approximal box-only cavities that are relatively small and limited to enamel were prepared. These small cavities were filled with a small amount of composite therefore less stress may have occurred due to polymerization shrinkage at the composite/tooth interface. This contributes to the reduction of microleakage values in rapidly

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polymerized groups. Although the size of the cavity and the resulting shrinkage stress are the subjects of another study, relatively small and enamel-limited box-only restorations can be polymerized by rapid polymerization methods according to findings of this study. Bayraktar et al. reported that rapid polymerization procedures can be used at small Class V cavities with selective enamel etching and sixth-generation adhesive systems [39].

The polymerization procedure of dental composites can be divided into pre-gel and post-gel phases. During the pre-gel phase, the internal stresses formed in the composite material during polymerization may dissipate and the tension is reduced. After the pre-gel phase, the material becomes more rigid and continuing the polymerization procedure results in tension at the tooth/restoration interface [40]. Therefore, it has been suggested that the polymerization should start with increasing low energy to extend the pre-gel phase [41,42]. However, Asmussen et al. revealed that polymerization shrinkage depends not only on the total amount of energy but also the combination of energy density and exposure time that affects the shrinkage pattern [43]. In the literature, different results were reported about the relationship between power density and polymerization shrinkage [43-47]. Further studies are needed to demonstrate the flow properties of the composite material during rapid or slow polymerization.

According to the findings of this study, the DC of composite materials were found to be similar between the groups that were polymerized at different power densities. The second null hypothesis was accepted. DC is an important factor for composite resin materials and refers to the conversion of carbon-carbon double bonds to monomeric carbonic to carbonic simple polymer [48]. DC can be analyzed through mechanical and spectroscopic methods. Spectroscopic methods provide direct measurements of DC values with more reliable results [49]. While higher DC leads to a better clinical performance of composite resin materials, a lower DC could cause unreacted monomers that lead to

degradation and that may affect the longevity of the composite restoration [50].

Light transmission depends on the opacity of the material. In general, bulk-fill composites exhibit higher translucency than conventional composites [51]. In addition, the 'Ivocerin' based initiator system has an absorption spectrum very close to CQ. It has been reported that photopolymerized activation is higher than CQ due to the absorption of visible radiation [32]. According to the results of this study, the bulk-fill composite resin with an 'Ivocerin' based photoinitiator system was found to have a higher DC than either of the conventional composites. The different polymerization modes used did not have any significant effect on the DC of the composites. These results are consistent with many studies in the literature [49,52,53].

According to the study, Clearfil Majesty Posterior showed a higher degree of conversion than Tetric EvoCeram. The differences in the organic matrix structure of the two composite resins have an effect on their degree of conversion. While the Tetric EvoCeram composite did not contain TEGDMA, the presence of this monomer in the Clearfil Majesty Posterior may have caused higher DC for the CMP group [54, 55]. TEG-DMA increases DC and crosslinking when mixed with Bis-GMA [55]. This finding can also be explained by the high organic matrix rate of Tetric EvoCeram (without TEGDMA monomer) as volume against Clearfil Majesty Posterior. [54,56,57].

Although there is no clear information on the clinically required DC value, it has been reported that this rate should not be below 55% [11]. Both the top and bottom surfaces of TEC-6 Group specimens showed less DC values than 55%. While the TEC-20 Group showed fewer DC at the bottom sides, the other groups showed higher DC levels.

In this study, DC and microleakage scores of the composites were evaluated but the interaction between the polymerization shrinkage, DC and microleakage scores could not be compared. Additionally, oral conditions could not be simulated properly. These factors

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are the limitations of the study. The interaction between DC, polymerization shrinkage and microleakage is a complex relationship, and further studies are needed.

CONCLUSION

Polymerizing composite resins with high-power density LED device in a short time did not affect DC. Small composite restorations with low C-factor may be polymerized in a shorter time with high-power LED devices. Further studies are needed to evaluate the relationship between DC, polymerization shrinkage and microleakage values of composite resins.

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