Microhardness of Two Composite Resins with Different Curing Sources

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Abstract

Background This study evaluated the influence of two light sources on the microhardness of two recent composite resins.

Methods A total of one hundred and twenty specimens were prepared and divided into two groups according to the composite resin restoration used (Tetric EvoCeram Bulkfill) and (Universal Nanohybrid Mosaic). Each group was subdivided into four subgroups according to the light source used with different curing intervals: laser curing system (SIROLaser) for 10,15, and 20 seconds and conventional blue light system (LED) for 20 seconds. Microhardness testing machine was used to assess the microhardness. Two-way ANOVA was done for comparing resin composite and curing energy effect on different variable studied. One-way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between each composite subgroups and t-test for subgroups. P values ≤ 0.05 are considered statistically significant in all tests.

Results LED cured Tetric EvoCeram Bulkfill composite resin recorded higher B/T ratio than laser cured one and the difference in B/T ratio between both energies was statistically non-significant. LED cured Mosaic composite resin recorded higher B/T ratio than laser cured one. The difference in B/T ratio between both energies was statistically significant.

Conclusion SIROLaser Blue laser device has been promoted for composite resin curing with different curing intervals, but the high cost and technique sensitivity result in their limited use.

Clinical Significance: Different types of curing systems are present in the dental practice. The use of SIROLaser Blue laser to photopolymerize composite resin will offers proper polymerization properties.

Background

Composite resin restorations have become the material of choice nowadays. [1] because of their esthetics, biocompatibility and adhesive properties. [2] Recently, many methods have been proposed to improve it is polymetric matrix and placement techniques. [3] A new composite resins were launched in the dental market, the so called bulkfill composites. This new composite resin inserted in 4 mm bulk placement instead of the current incremental placement technique with low polymerization stresses and high reactivity to the light cure. [4] Proper curing of composite resin restorations is effective factor influences the good physical and mechanical properties and biocompatibility of the material. [5] There are four main types of light curing units; Quartz-tungsten-halogen (QTH), Light-emitting diode (LED), Plasma Arc (PAC) and Laser based units. [6] Dentists should carefully select the curing light source as it literally influences the success of photo-cured restorations. [7] Microhardness evaluation is a reliable technique that determine the depth of cure and it has a clinical aspect of composite curing. [8] This study evaluated the influence of SIROLaser and LED curing units on the microhardness of Bulkfill composite resin and nanohybrid universal composite resin.

Methods

A total of one hundred and twenty cylindrical specimens were prepared and divided into two groups (60 each) according to the type of composite resin used. Group A: Bulk Fill composite resin (Tetric EvoCeram, Ivoclar Vivadent, USA) and Group B: Nanohybrid universal composite resin (Mosaic, Ultradent, USA). Each group was subdivided into four subgroups (15 each) according to the different curing technique; Subgroup 1: subjected to 10 seconds of laser curing, Subgroup 2: subjected to 15 seconds of laser curing, Subgroup 3: subjected to 20 seconds of laser curing, and Subgroup 4: subjected to LED curing for 20 seconds. Microhardness test was done for all specimens on both top and bottom surfaces. (5) The size of the specimen was 4 mm diameter X 6 mm thickness and prepared in a Teflon split mold. The mold was made of circular Teflon disk milled with specific dimensions (30 mm in diameter and 6 mm in thickness), three cylindrical holes were drilled vertically in the mold, aligned with the longest diameter of the disk and finally the disk split horizontally through the diameters of the aligned holes to make the split mold symmetrical. The two halves of the mold are assembled with circumferential cupper ring with 35 mm diameter and 3 mm thickness. Mylar strip was placed on a glass slap and the Teflon mold was placed over it. The composite resin material was packed inside the mold. Another Mylar strip was placed over the composite resin and another glass slide was slightly compressed to extrude excess material and to keep the distance between the curing tip and the mold is fixed at 5 mm. Tetric EvoCeram Bulkfill was packed in two increments (to 2 mm height mark from the bottom and curing, then to the top edge of the mold surface) to keep the thickness of each step does not exceed 4 mm thickness. Mosaic resin composite was packed into the mold in 2 mm thickness increments from the bottom of the mold to the top with curing each increment. The composite resin packed and adapted into the mold using Teflon plated non-stick composite placement instrument. Two types of curing systems were used: LED light curing, (BlueLEX LD-105, Monitex) with 2000mw/cm^2 was used according to the manufacturer instructions for 20 seconds and laser system, (SIROLaser Blue laser, Sirona) with wavelength 445 nm and 500 mw/ cm^2. The light tip was in direct contact with the glass slap on the top surface of the glass slap over the mold through the different time intervals (10 sec., 15 sec. and 20 sec.). After photo-activation, the mold dissembled and the top and bottom surfaces of each specimen (Fig. 1) was finished and polished using super fine bur (SF 30 μ, Mani diamond burs, China) and rubber polishing cup then stored dry in incubator at 24^{0}C temperature for 24 h before testing. Vickers hardness number (VHN) was determined on the top and the bottom surfaces for each specimen using a microhardness testing machine (HV-1000DT, Shanghai Daheng Optics and Fine Mechanics Co, Ltd) equipped with a diamond pyramidal microindentor to apply a load of 300 g for a 15 seconds(9) at room temperature. The VHN for each surface was recorded as the average of the three readings. Each specimen was positioned underneath the indenter of the microhardness tester to determine the mean Vickers hardness number (VHN) on the top and bottom surfaces. After positioning the specimen, the clearest vision of the specimen surface checked through the 40X objective lens. A 300 g load was the applied through the indenter with a dwell time of 15 seconds. After complete undwelling of the indenter, the 40x objective lens repositioned over the specimen surface to adjust the diameter two longitudinal lines to measure the length of D1 and D2 diagonal lines, then the D1 and D2 value interred to the hardness tester through the digital panel, then after pressing the OK button, the tester measures the mean hardness value. Three readings were taken on the top and the bottom surface for each specimen. Two-way ANOVA was done to compare the composite resin and curing energy effect on different variable studied. One-way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between each composite subgroups and t-test for subgroups. Statistical analysis was performed using Asistat 7.6 statistics software for Windows (Campina Grande, Paraiba state, Brazil). P values ≤ 0.05 are considered statistically significant in all tests.

Results

LED cured Tetric EvoCeram Bulkfill composite resin recorded higher B/T ratio than laser cured one and the difference in B/T ratio between both energies was statistically non-significant. LED cured Mosaic composite resin recorded higher B/T ratio than laser cured one. The difference in B/T ratio between both energies was statistically significant. Table (1) Figure (2)

Table (1)

Comparison of B/T ratios (Mean values ± SDs) between light cure sources and composite resins

Variables	**Tetric EvoCeram** **Mean ± SD**	**Mosaic** **Mean ± SD**	***t-test***
Laser (10 S)	$92.01^{a} \pm 7.48$	$45.89^{b} \pm 4.23$	< 0.0001*
Laser (15 S)	$94.32^{a} \pm 5.11$	$51.36^{b} \pm 8.92$	< 0.0001*
Laser (20 S)	$91.97^{a} \pm 5.05$	$50.23^{b} \pm 4.80$	< 0.0001*
LED (20 S)	$92.08^{a} \pm 6.73$	$90.85^{a} \pm 9.90$	0.9818 ns
P-value	0.8792 ns	< 0.0001*	
Different letter in the same column indicating statistically significant difference (p < 0.05)*; significant (p < 0.05) ns; non-significant (p > 0.05)			

Discussion

During the placement of composite resin restoration, the quality of polymerization has a great impact on the material. Therefore, new technologies have been developed to produce appropriate light amount which influences the physical and mechanical properties of the materials.[10] The type of curing light and curing mode had great impact on the quantity and quality of the composite resin polymerization. [11] LED light cure was proposed by Mills in 1995 to polymerize composite resins. [12] It emits light at specific wavelength within 400-nm to 500-nm photoabsorption range of camphorquinone (CQ).[13] Camphorquinone (CQ) is considered as the conventional photoinitiator system in composite resins and it absorbs light most efficiently at approximately 460–470 nm. Newer types of photoinitiators such as diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide (TPO) and Ivocerin absorbs light most effectively within lower wavelength range and act as substitute for the CQ to reduce the yellow coloration.(14) Therefore, manufacturers started to use these photoinitiators to produce restorations of high color value with high reactive initiators that increases the depth of cure, especially with the bulkfill composite resins which contains TPO and Ivocerin photoinitiators.(7) They absorb the light in different wavelength range than camphorquinone (CQ) even with low wavelength range (380– 420 nm). New LED light cure, poly wave emitting multiple wavelengths was introduced such as the light cure used in this study (BlueLEX LD-105, Monitex©) which has the advantage of curing composite resins that contain more than one photoinitiator with different light absorption spectra.(15) Laser system (SIROLaser Blue©– SIRONA, Germany) was the first dental diode laser with blue, infrared, and red diode that contains Blue diode laser and produces 445 nm wavelength. Surface microhardness of composite resins has been used to evaluate the efficiency of the light cure unit and to evaluate the extent of polymerization indirectly. (16) The results of this study showed that Vickers microhardness of Tetric EvoCeram composite resin group top surface with 10 seconds laser cured subgroup recorded the highest mean value followed by 20 seconds LED cured subgroup followed by 15 seconds laser cured subgroup and the lowest subgroup was the 20 seconds laser cured. Also, the Vickers microhardness of Mosaic composite resin group top surface with 15 seconds laser cured subgroup recorded the highest mean value of Vicker microhardness followed by 20 seconds LED cured subgroup followed by 10 second laser cured subgroup and the lowest subgroup was the 20 seconds laser cured. These results agreed with Ceballos et al., (17) who stated that the interactions between light curing source and exposure time and between light curing unit and depth significantly influence microhardness results. High microhardness values may be related to the type and concentration of photoinitiators (18) and to the materials composition. There is a positive relationship between microhardness and the inorganic particle content, as increasing the filler content will result in higher microhardness.(19) Dickens et al.,(20) stated that the hardness of the composite resin affected by the crosslinking and the network formation that occurs during setting. Network formation occurs after an initial stage of polymer chain propagation. Tetric EvoCeram composite resin has different types of photoinitiators like camphorquinon and Ivocerin and different filler particle size and amount (81% wt, 61% vol)(21) which increase the ray light scattering.(22) Some of the low wavelength photons will reach the bottom thickness of the composite resin and the other photoinitiators will have to be activated by the less efficient longer wavelengths of light. This may explain why some researchers found that the microhardness of the bottom surface cure of filled camphorquinon based materials can be significantly greater than that of TPO-based materials using a light cure unit that delivered the greatest light output in the 450–500 nm range. (23) On the other hand, Dionysopoulos et al., (24) found no significant differences in microhardness between different types of the composite resins tested in their study. This could be related to the difference in the composition of the composite resin as they used nanocomposites and, in this study, we used bulkfill nanohybrid and universal nanohybrid composite resins in addition to the difference in the tested methodology. Also, Aguiar et la., (25) in his study showed an improvement of hardness means with an increase of the light curing time, mainly on the bottom surface. The results of this study showed that regardless to curing energies it was found that Tetric EvoCeram resin composite resin recorded statistically significant higher (B/T) ratio than Mosaic composite resin. This is agreed with Hubbezuglo et al., [8] who stated that irrespective of the light curing unit used, bottom surface hardness values were lower than those of the top surface of all the materials tested. This could be related to the reduction in the light intensity as it passes through the bulk composite resin which result in low absorption and scattering of light by the fillers and matrix [26] which result in difference between top and bottom surface hardness of different materials with different light cure sources. [8] and this was agreed with our results as laser curing energy did not improve the hardness of the composite at 4 mm thickness of Mosaic in relation to the hardness values of bottom surface for Tetric EvoCeram resin composite. Another explanation of this result is related to the composition of the materials, which influences the translucency, and consequently the energy density that reach the lower layers of the materials. Microhardness of composite resin material does not reflect only the extent of polymerization, but other factors such as filler content (Tetric Evoceram fillers are Barium glass, ytterbium trifluride, mixed oxide and prepolymer and Mosaic fillers are Ceramic zirconia silica glass and filler size (Tetric EvoCeram fillers size: 40 nm-3,000 nm, mean size: 550 nm and Mosaic fillers size: 0.02 um) that affects hardness results. [27] It depends also on other factors, such as the organic matrix composition (Tetric EvoCeram organic matrix: Bis-GMA, Bis-EMA, UDMA [21] and Mosaic organic matrix: Bis-GMA, PEGDMA, TEGDMA) [28] as the polymerization level varies according to the amount of monomers and oligomonomers present in the composite resins [19] Also, Young's modulus of elasticity and viscosity plays major role in the microhardness results. The composite resin viscosity is correlated with the type of resin matrix. Bis-GMA as the most viscous one is also least flexible, while UDMA and TEGDMA are least viscous. [21] The results of this study showed that LED cured Tetric EvoCeram composite resin recorded higher B/T ratio than laser cured one. The difference in B/T ratio between both energies was statistically non-significant. So, regarding to the type of composite laser curing light device cured photoactivated Tetric EvoCeram dental composite materials and provided a hardness value as efficient as conventional LED light curing devices but with shorter time. For Mosaic resin composite it was noted that, LED cured Mosaic composite resin recorded higher B/T ratio than laser cured one. This could be related to different factors which affects microhardness results such as the power of the light source, the quality of the light source, the distance between the light end and the composite surface, the layer thickness of the applied composite, the color of the composite and the composition of the organo-inorganic structure in the composite vary depending on the composition. [9] In addition to the fact that long time exposure to laser in the continuous mood, may leads to heat generation on the outermost layer of the composite. Heat transmission to the materials may result in reduction in the hardness as the heat increase the monomer mobility by decreasing the cross liking and change the filler distribution on the outer top layer facing the laser source as agreed with Harrington and Wilson [29] and Manhart et al. [30] So, proper selection of the light curing unit and an adequate time for photopolymerization will result in satisfactory composite resin especially in deep cavity preparations. [25]

Conclusion

SIROLaser Blue laser device has been promoted for composite resin curing with different curing intervals, but the high cost and technique sensitivity result in their limited use.

Clinical Significance Different types of curing systems are present in the dental practice. The use of SIROLaser Blue laser to photopolymerize composite resin will offers proper polymerization properties.

Abbreviations

QTH
Quartz-tungsten-halogen
LED
Light-emitting diode
PAC
Plasma Arc
Bis-GMA
Bisphenol A-glycidyl methacrylate
Bis-EMA
Bisphenol A diglycidyl methacrylate ethoxylated
UDMA
Urethane Dimethacrylate
PEGDMA
Polyethylene glycol dimethacrylate
TEGDMA
Triethylene glycol dimethacrylate

Declarations

Ethics approval and consent to participate

Not applicable

Consent to publish

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

EA designed the study and performed the experiments. MA participated in data collection, revised the Background, Discussion and Conclusion sections. All authors read and approved the final manuscript.

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Figures

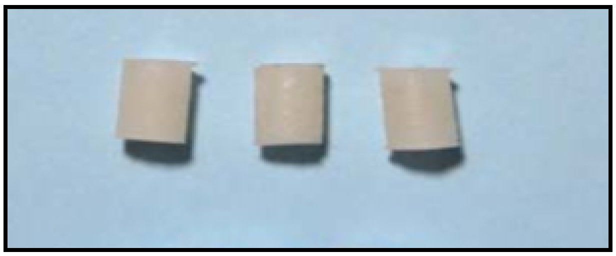

Figure 1

The cured specimens after dissembling the mold

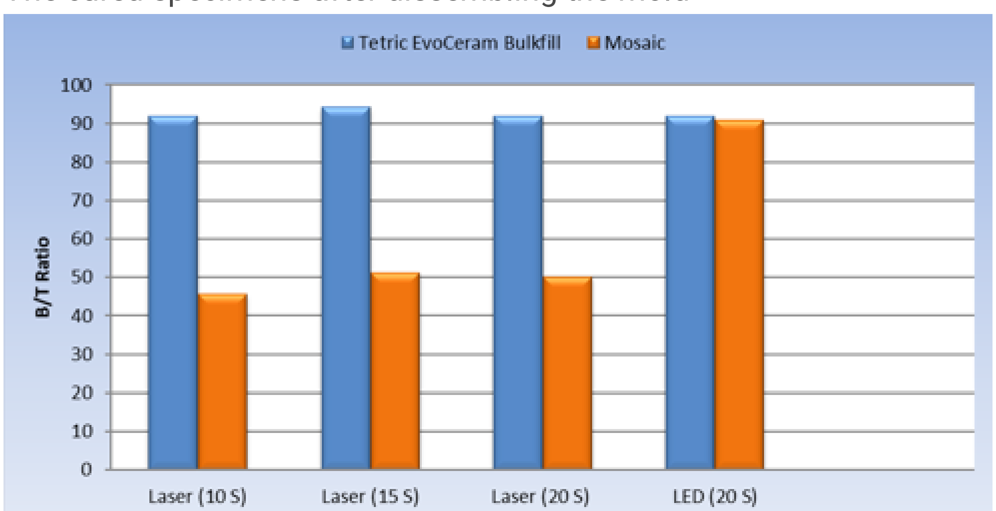

Figure 2

Column chart of the mean values of B/T ratio for different light sources with composite resins