Review Article

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Investigating the Effects of LED and QTH Light Cure Devices on Composite Hardness

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ABSTRACT

BACKGROUND AND OBJECTIVE: Light cured composites allow dentists to begin the process of polymerization on demand. According to the importance of curling on the mechanical properties of composites, the purpose of this meta-analytical study is to compare the effectiveness of light curing LEDs and QTH devices on the hardness of composites.

METHODS: In this meta-analysis review articles from the PUBMED, SCOPUS, and ISI databases were analyzed without any limitations in language or time, to compare the hardness of composites after curing with LED and QTH devices .Two analyzes were carried out with out any limitation in time or language, with a radiation intensity of less than 500 and more than 500 mW/cm2. The thickness of the cured composite in both groups was considered to be 2 mm. Non-matched articles with the variables mentioned in the study were deleted. Data were analyzed using the random effects model (α=0.05).

FINDINGS: Using the random effects model, there was no significant difference between the hardness of 2 mm thickness of the composite after curing with LED and QTH at light intensity higher than 500 mW/cm2 (p = 0.43) but there was a significant difference (p=0.000)at an intensity less than 500 mW/Cm2.

CONCLUSION: The lightcure LED device was better in terms of its effect on the hardness of composites at below 500 mW/cm2 intensity than QTH, but did not show differences at higth intesity.

KEY WORDS: *Composite Resin, Hardness, Curing Ligth.*

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Introduction

From the beginning of the emergence of dentistry, many efforts have been made to make a material that can withstand the needs of beauty and has good biological mechanical properties. Ligth cure base resin composites were one of the first cosmetic restorative materials for the anterior and posterior teeth. Lightweight composites allow dentists to start the process of polymerization initially, one of the advantages of these composites to self-cure composites. Suitable curing of optical composite restorations is necessary to achieve the physical properties expected of the structure (1).

Inadequate exposure results in a reduction in degree of conversion, increased toxicity, reduced hardness, increased pigmentation, reduced flexural strength, increased wear, increased margin fracture and poor bonding (2). Many of the light cure composite resins use starting ketone, such as camphorquinone, which absorbs light photons mostly at 474 nm. There is a relationship between the diffusion of the output spectrum of the light source and the maximum absorption of the initiator on the physical properties of the cured composite (1). Therefore, the type of light cure device is very effective in reducing the polymerization quality of composites (2). Quartz, Tangestan Halogen (QTH and LED) Ligth emidding diode are the most common sources of light cure that are used in dentistry.

QTH creates a wide range of wavelengths that peak in devices ranging from 450 to 490 nm, so that different initiation molecules that are substitutable for camphorquinone can be used (3). QTH bulbs have been standard for the long-term standard of the optical system for many years, despite comparatively low thermal performance. Compared to LED, QTH has a narrow wavelength range in the range of 450 to 490 nm, and has a longer life-span, which does not affect their light power after a long time. However, the LED has a narrow wavelength spectrum which does not polymerize well composite resins that contain alternate initiators (monoacrylic phosphonyl oxide or TPO390 nm or phenylpropionone or PPD410 nm) due to the different wavelengths of these optical initiators (3).

Curing depth and surface microprocessor tracking are the main parameters for evaluating the polymerization of the composite and the efficiency of the light source. Fugolin et al showed that the degree of polymerization of the composites is related to their hardness (4). In a study, Movafy et al. (5) showed that composite hardness is similar with both light cure devices. Yap et al. (6) and Platt et al. (7) and Santos et al. (8) also reported similar results. On the other hand, Yap et al. (2004) showed that composite polymerization using halogenated devices is more than types of LED. Soh et al (10) also give a similar view. Due to the different results of these two devices and the importance of sufficient curing of composites, the aim of this study is to evaluate systematic and meta-analyzing the effects of these devices on the resin composite hardness.

Methods

This systematic review study was based on PRISMA (prior items in systematic review and meta-analysis) and AMSTAR (evaluation of methodological qualitative criteria in systematic reviews). Information obtained from this study consists of 3 databases, pubmed, scopus, and ISI using the key words Bonding * OR Composite * OR Sealant * OR Resin * OR Teeth Or Tooth OR Dental OR Emal OR Dentin) AND ((led OR "light emitting diode") AND (QTH OR "quartz tungsten halogen") AND (light cure OR light curing). This search used a combination of controlled words and terminology to extend search strategies to the above mentioned bases without any restrictions in language or time.

In the search , 261 articles from Pubmed and 178 articles from ISI and 277 articles from Scopus were obtained. To complete the articles, a manual search was made in the references of the articles. Out of the 17 final papers on the effects of two light cure QTH and LED devices on composite hardness, 7 papers were accepted according to our entry criteria and then evaluated with critical tools in this study, and 3 articles due to lack of full text were excluded after contacting to the author by email and did not receive a response, and 7 articles were excluded from the list due to non-compliance with the study.

Articles with the following characteristics were included in the study:

1- Composite thickness: 2 mm, which was used in most papers.

2- Exposure intensity: In terms of intensity of exposure in two QTH and LED devices, ranges of above 500 and below 500 (Mw/cm2) were further considered.

3- composite hardness measurement was performed by Vickers or Knoop method.

Articles with the following features were excluded:

1.Studies using composite thicknesses other than 2 mm.
2.Studies with an exposure intensity of less than 360 mW/cm2.
3. Studies used exposure times greater than 40 seconds or less than 20 seconds.
4. Review articles

The data included in the study were analyzed using statistical variables including sample size, mean and standard deviation. The analyzes carried out consisted of two analyzes of high intensity and below 500 mW/cm2 in a 2 mm thick composite. After extracting the sample size, the mean and standard deviation of the selected studies data were entered into the Comprehensive Meta-Analysis, Version 2, Biostat software. Then, Forest Plot and relevant statistics were extracted by the software.

Results

In the preliminary search, 330 studies were found that after the removal of similar studies (duplicates) and non-related studies, 7 studies were entered this research for scientific and statistical evaluation according to entrance criteria (Fig 1). The characteristics of the entered studies were shown in Table 1.

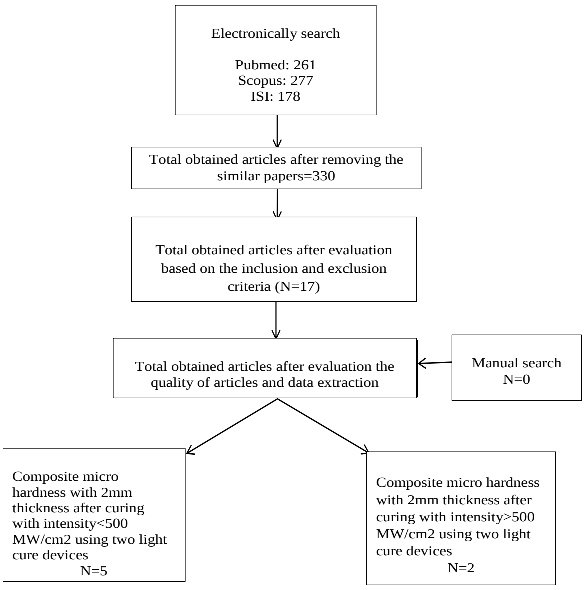

Figure 1. PRISMA Flow chart of entered articles in this study and search strategy

To determine the statistical model used to calculate the overall effect of the results, Cochrane Q homogeneity test was used and the significance level of 0.05 was considered. Therefore, the I2 index was used to determine the amount of heterogeneity and values above 50% were considered as high heterogenicity.

Table 1. Characteristics of studies included in the analysis

Name of authors	Type of device	Exposure intensity (MW/Cm2)	Exposure time (Sc)	Composite thickness (mm)
Araujo[11]	QTH-LED	500	40	1,2
Castillo[12]	QTH-LED	850,950	20,40	1,2
Correr[13]	QTH-LED	440,700	20	1,2
Groninger[14]	QTH-LED	700	40	2
Hegdem[15]	QTH-LED	600	40	2,3
Rode[16]	QTH-LED	400,600	30	2
Sabatini[17]	QTH-LED	600	40	2

According to the test, the homogeneity of the averages was rejected. Therefore, a random-effect model was used to analyze the results. In analysis, according to the severity of curing, using the random effects model (Fig 2), there was a significant difference between the hardness of the composite mass at a thickness of 2 mm following the curing with LED and QTH at exposure intensities below 500 MW (I2= 96, Q=326.72, p=0.000). At exposure intensities above 500 MW/cm2, using a randomized model, it was shown that there was no significant difference between the hardness of the composite mass in a thickness of 2 mm after the curing with LED and QTH (Fig. 3) (I2=91.25, Q=274.38, p=0.43).

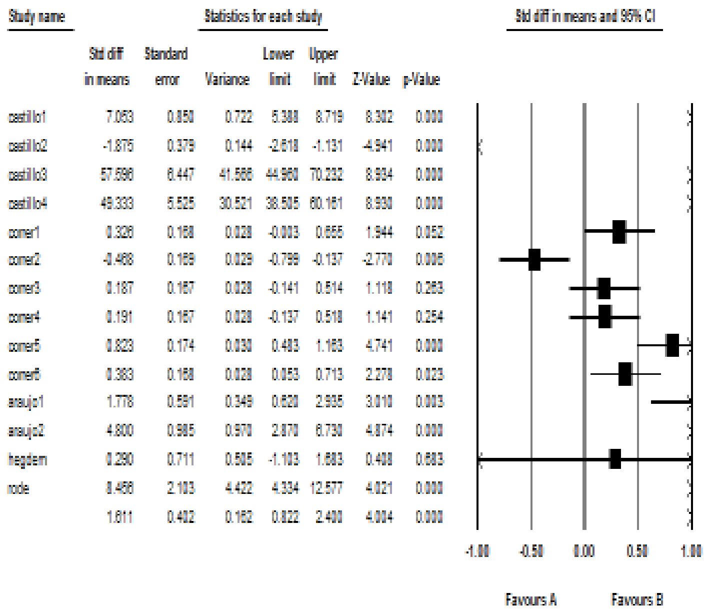

Figure 2. Forrest plot comparison of composite hardness after curing with LED and QTH in exposure intensity below 500 mw/cm2

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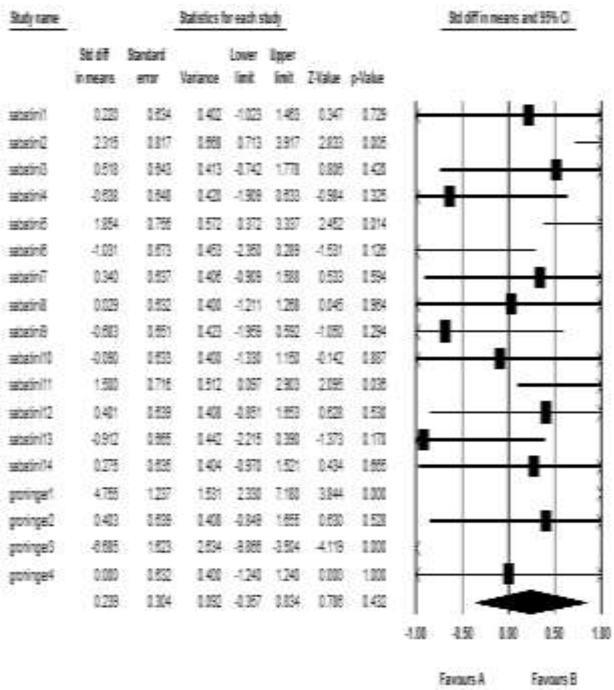

Fig. 3. Forrest Plot Comparison of Composite Hardness after Curing with LED and QTH in Exposure intensity above 500 MW/Cm2

Discussion

This meta-analysis study showed that there is a significant difference between the hardness of composite mass of 2 mm thickness after the curing with LED and QTH at radiation intensities below 500 MW/Cm2. But in radiation intensities above 500 MW/Cm2, there is no significant difference between the hardness of composite mass of 2 mm thick after the curing with LED and QTH. Since most of the papers used 2 mm composite thickness and commonly used composite thickness in the clinic, only studies that measured the thickness of 2 mm were introduced. Correa in a study stated that composite thickness up to 2 mm had no effect on the composite hardness between two light curing devices (13). In general, for optimal polymerization, a composite resin restoration of 2 mm thickness, the intensity of the device and sufficient time for radiation are important which is referred to as "energy density" (Exposure intensity*time). All the articles entered in this study had exposure times in the range of 20 to 40 seconds, which is an accepted time within the clinical range. Felix et al. showed that exposure of composites in less than 20 seconds would weaken their structure (18).

In the intensity of exposure in two QTH and LED devices, a range of less than 500 and more than 500 (Mw/cm2) were further considered, which from the first 17 papers on the impact of QTH and LED on composite hardness, 10 papers investigated this subject. In other papers, the intensities were much lower, such as 131 and 190 (Mw/cm2). Since exposure intensities of less than 360 mW/cm2 are not suitable for composite cure, studies that investigated less that this intensity were excluded from our study (20, 19). Taking into account these two factors the time and intensity of the radiation, a composite mass of 2 mm thick requires a minimum radiation exposure of 28 J/Cm (2400 MW/cm2).

A study by Yaman and colleagues to compare the effects of two types of Hilux, VIP and two types of light-emitting diodes (Elipar free light2, Smart Lite) on the depth of curing and the micro hardness of different restorative materials showed that there is a significant increase in the curing depth and surface hardness of the nanocomposite in the LED type compared to halogen, which was evaluated due to the high thickness of the composite, and was excluded from our study (21).

The radiation intensity of both devices in this study was below 500 mW per square centimeter and therefore the results are consistent with our study. In studies by Marchan et al. (22), Kusgoz et al. (23), and Habbzoglu et al. (24), because the LED group was below 500 and the QTH group with a severity of over 500, were not classifiable, the composite thickness was below 1 mm or the difference in intensity above 500 was very high (530 and 1200), were excluded from our study. Polymerization depends not only on the intensity of light, but also on the total amount of light transmitted along the length of the polymer. Therefore, a possible reason for the better LED performance at low radiation intensities may be related to the density of LED energy with resin composite pigments, while these pigments result in the diffusion of light due to QTH, so that the total light output to the composite in the LED is greater (24).

On the other hand, LEDs have a thin diffraction spectrum similar to the Camphorquinone absorption spectrum. This spectral homogeneity allows full use of the light emitted by LEDs, which is not the case with halogen or plasma arches. It has been shown that light blue in various portions of the spectrophotometric absorption of Camphorquinone produces different levels of curing efficiency and that light is very effective in the vicinity of the absorption peak in the cure [3]. Therefore, the factors and the proximity of the absorption spectrum of the LED to the camphorquinone cause the LEDs to perform well even at low energies and have a higher performance than halogenated types. On the other hand, at high intensities, this study showed that there is no difference between the two devices, and the performance is the same. Since high intensities are associated with higher heat production, it seems that the use of LEDs with intensities below 500 mW per cm is also sufficient to make the composite hard enough, although it is not possible to give a definite opinion according to a hardness criterion.

Since the seven articles in this review are all intra-laboratory studies and are therefore classified as preliminary studies, the level of evidence is low, and because of this concern, high credibility articles and methodology and standardization of the method, calibration of observers, accurate data reporting and appropriate statistical analysis based on data distribution were included in the study. Most of the journals in this research were effective scientific journals. Despite the fact that randomized clinical trials and clinical studies have high evidence, these studies have not yet been released to evaluate the efficacy of light cure devices. Since only the composite hardness cannot be a suitable criterion for determining the superiority of a curing device, it is suggested that studies on the effect of these two devices be adjusted on other mechanical properties of composites. The results of this study showed that LED light cure device in low intensity (less than 500 MW/cm2) could polymerize the composite and affect its hardness better than QTH device, but at higher intensities, there is no difference between the two devices.

Conflict of Interest: No conflicts of interest.

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