Polymerization efficiency of curing units in dental offices

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Summary

***Objectives*. The objective of our study is to evaluate the yields of curing lights and to inform Istanbul-based dentists about light-curing devices.**
***Materials and Method*. Brightness values of 156 general practitioners' clinical halogen units are measured in 3 different districts of Istanbul. CM-300 brand name radiometer is used for the measurements.**
***Results*. Most of the halogen based devices show low polymerization efficiency due to cracked fiber tips and old lamps. Practitioners that only regard the composite material manufacturer instructions are informed about this issue to improve polymerization efficiency.**
***Conclusion*. Light-curing unit's brightness value will decrease over time and, consequently, polymerization effectiveness will be weakened. For dentists who do not regularly service their light-curing units it is better to work with light emitting diod included systems because of the advantages over quartz tungsten halogen units.**

***Keywords*: Light curing, QTH, light intensity, led, polymerization.**

Introduction

Today, the increasing demand for aesthetic vision is making the composite resin restorations developed by Bowen in 1962 ever more popular [1]. Initially, polymerization occurs while the two paste materials are being mixed; but since 1972, UV polymerization methods have been in use.

Because of the possible harmful effects of the UV source to the patient and the dentist, the use of UV light was stopped and visible light began to be used. [2]

Lamp included systems have been used for a long time. In these kinds of systems there are tungsten filaments in the halogen gas containing lamps. This filament gives out a powerful heat by the way of electromagnetic energy in the form of invisible light. This event is explained by the electromagnetic energy, which a heated object gives off. Every increase in temperature increases the wave width, length and depth of the blue light [2,3]. The yield of the bulb is affected by the voltage. Quartz tungsten halogen bulb systems emit the needed lights of wavelengths and also put out lights of wavelengths that are not affected by the composite polymerization. These curing units have lamps that release light between 380 nm and 760 nm in wavelength. There are filters in the systems that filter this wavelength to 400-470 nm and selectively activate camphorquinone for polymerization. The energy that is used for polymeriza-

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tion in the conventional system is between 2% and 0.7% of the energy used by the machine. The rest of the energy forms heat and is ejected by the fan at the end of the unit. The use of only a small part of the total energy used by the machine is a question mark for the productivity of these curing units. On the other hand, filters that eliminate the unusable wavelengths and the fan for the excessive heat transmission make these machines bulky. [4-5]

A typical quartz tungsten halogen bulb lifetime is limited by the 80-100 usage hours. This depends on many factors such as usage conditions, restoring of filter systems and voltage. The light that is produced by the bulb passes through the filter systems and, by the fiber optical tip, it is transmitted outside the curing device. Part of the light source disappears in this optical tip. Standard polymerization units' tips are mostly 11 mm. The narrowness of these optical tips increase light energy and also the temperature. Over 42.5 degrees of temperature increase in the pulp during the restorative process may cause irreversible harmful effects to the pulp tissue [6-7]. Heat transfer during polymerization has changed due to the units [8]. The new halogen polymerization units designed to increase the light irradiation yield could increase heat transfer to the pulp [9]. At the quartz tungsten halogen units, it is seen that decreases occurred while going from the center to the sides. Optical tip should be an optimum of 2 mm away from the material that will be polymerized. In addition, the light-curing unit's bulb, reflector and filter degrade over time due to the high operating temperatures and the large quantity of heat, which is produced during the duty cycles. This results in a reduction of the light-curing unit's curing effectiveness over time [10,11,12,13]. Plasma arc curing units introduced to dental usage after halogen lamp based ones have advantages such as shorter curing time and less heat transmission due to the usage time. The plasma arc unit has much higher light intensities [14], compared to halogen based curing units. But in these curing units, because of the higher intensity, more polymerization shrinkage and micro leakage can be seen. Despite the advantage of lower temperature, the units have not kept their popularity for long [15]. To overcome the problems inherent to halogen light-curing units, solid state light emitting diode (LED) technology has been proposed for curing light activated dental materials [16].

In recent years, concentrated light source, lower voltages, and spreading through limited wave length, newly developed, high degree irradiation of blue light diodes (LED) have started to be researched [2,17,18,19].

A known amount of energy is required in order to initiate the photo activation. Monomer changing degree depends on this. This is important in the spreading of energy through the material [3].

The properties of the systems could be changed by the parameters of the photo activation such as monomer exchange, polymerization shrinkage, mechanical properties, light source, and curing time [20]. In general, high light source usage is advised by the researchers. Thus high light source could increase to exchange the monomers. Despite this, some researchers claim that the use of higher light source causes higher polymerization shrinkage and stress.

Curing time of decided light noticed the total numbers of the free radicals and brightness indicates the amount of photon transmission and free radicals.

For adequate polymerization of 1 mm increment of composite, the advice is that the light must be exposed for 60 seconds and the intensity should be 280 mw/cm^2 or 2 mm increments – 60 seconds and 400 mw/cm^2 [21,22,23]. These examples can be expanded but there is no agreement about the exposure time and precise light intensity.

The reasons for the decreasing brightness of the halogen units over time are filter systems, decrease of producing of the halogen bulb energy.

According to the ISO standards, while evaluating the yield of a curing unit, brightness and lower surface of a polymerized material value should be equal to or more than 80% of the upper surface of the material [24].

The objective of our study is to evaluate the yields of curing lights and to inform Istanbul-based dentists.

Materials and Method

In our study, the brightness values of 156 general practitioners' clinical halogen units are measured in 3 different districts of Istanbul. CM-300 brand name radiometer is used for the measurements. Before the measurement, the polymerization unit is run for 40 seconds and then light is sent to the radiometer for 40 seconds without any distance and the highest score has been noted. Then practitioners were asked about the curing time for bonding agents and the composite restorations.

Results

According to the measured values, brightness values of 26.9% of the light-curing units are below 300 mw/cm². In addition, only 50% of them measured over 500 mw/cm². 19.8% of the units give values below 200 mw/cm² (*Chart 1*). 112 of the 156 dentists said that they cure the composite resins in 2 mm increments according to manufacturers' instructions. The rest of the practitioners cure the composite more than 40 seconds and only 8 of them make post cure treatment (*Chart 2*).

Chart 1.

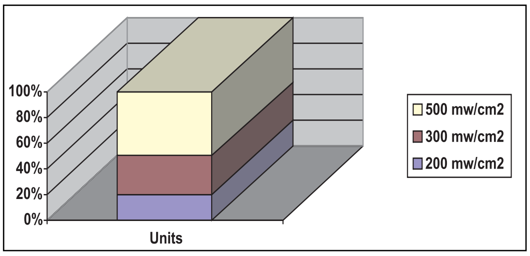
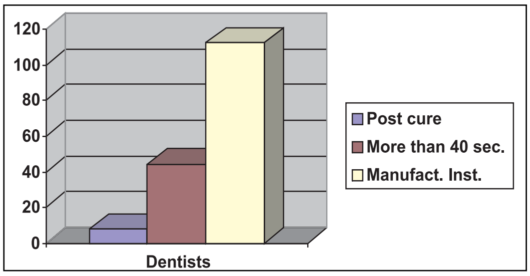


Chart 2.



Discussion

Decrease in the output of light weakens the polymerization of restorative materials, so that their properties are affected [12,13,25].

If there is an inefficient polymerization of restorative material, the mechanical and physical properties of the restorative material could be affected and there could be micro leakage, discoloring, increased roughness, increased water absorbtion, decrease of adhering of the restoration, missing of restoration and pulpal reactions [26,27]. In general, a polymerization of a resin composite is influenced by the composition of a material, general situations of the polymerization and the properties of the light-curing unit [28].

In our study of general practitioners' dental offices, we have found that most of the dentists follow the instructions issued by the manufacturers during the polymerization of the composite materials.

Unfortunately, manufacturers only give advice about the curing time and the incremental thickness of the material. They do not give any information about the required brightness values. Unless the polymerization process needs 20 or 40 seconds for the composite materials that are sold in the market, it is obvious that 50% of the light-curing units would not support efficient polymerization for the application of any incremental thickness of these materials. Besides, it is declared that in general, required curing times are also not efficient in complete polymerization.

As Yoon et al. mentioned that the degree of the polymerization of the materials directly related to the light exposed. On the upper level of the restoration, lower and higher intensity light results in nearly same polymerization efficiency [2]. One of the major criteria for polymerization success is to be able to support penetration of light through the deepest points of the composite [20]. It is known that in general, dentists take into account the upper surface of the polymerization of the material to evaluate the polymerization quality during the composite restoration. Nevertheless, it is necessary to exchange the lower surface monomers in the optimum conditions.

Nomoto noticed that increasing curing time compensates for lower light power [13]. But he explained that light power is more effective on polymerization and it is the main factor at the initiation of photo activation. Higher light power gives monomer mobility, decreases viscosity and thus increases the degree of polymerization.

In practice, using inefficient lamps increases the possibility of the inefficient curing of these materials. It is clear that brightness, curing time, and incremental thickness values are needed to be able to supply the composite polymerization [2,18,29]. If this is done, the lower mechanical properties due to inefficient light-curing and higher temperature due to the over-light-curing could be reduced or eliminated.

Conclusion

According to our research and our findings, dentists should be informed especially about the following subjects:

Light-curing unit's brightness value will decrease over time and, consequently, polymerization effectiveness will be weakened.

Light-curing units should be checked by the radiometer periodically.

For dentists who do not regularly service their light-curing units it is better to work with light emitting diode included systems because of the advantages over quartz tungsten halogen units.

Success in the polymerization process should be achieved by increasing the polymerization time period.

While the dark colored composites are being polymerized, to increase the penetration of polymerization of deep points, the depth of the material should be reduced and the time of polymerization should be extended.

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