INFLUENCE OF LIGHT CURING SOURCE ON MICROHARDNESS OF COMPOSITE RESINS OF DIFFERENT SHADES

ABSTRACT

Introduction: The evolution of light curing units can be noticed by the different systems recently introduced. The technology of LED units promises longer lifetime, without heating and with production of specific light for activation of camphorquinone. However, further studies are still required to check the real curing effectiveness of these units. Purpose: This study evaluated the microhardness of 4 shades (B-0.5, B-1, B-2 and B-3) of composite resin Filtek Z-250 (3M ESPE) after light curing with 4 light sources, being one halogen (Ultralux – Dabi Atlante) and three LED (Ultraled – Dabi Atlante, Ultrablue – DMC and Elipar Freelight – 3M ESPE). Methods: 192 specimens were distributed into 16 groups, and materials were inserted in a single increment in cylindrical templates measuring 4mm x 4mm and light cured as recommended by the manufacturer. Then, they were submitted to microhardness test on the top and bottom aspects of the cylinders. Results: The hardness values achieved were submitted to analysis of variance and to Tukey test at 5% confidence level. It was observed that microhardness of specimens varied according to the shade of the material and light sources employed. The LED appliance emitting greater light intensity provided the highest hardness values with shade B-0.5, allowing the best curing. On the other hand, appliances with low light intensity were the least effective. It was also observed that the bottom of specimens was more sensitive to changes in shade. Conclusion: Light intensity of LED light curing units is fundamental for their good functioning, especially when applied in resins with darker shades.

Uniterms: Microhardness; Curing equipment; Composite resins; Shades

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INFLUÊNCIA DA FONTE DE LUZ POLIMERIZADORA NA MICRODUREZA DA RESINA COMPOSTA DE DIFERENTES CORES

RESUMO

Introdução: A evolução dos aparelhos fotopolimerizadores pode ser notada nos diferentes sistemas introduzidos recentemente no mercado. A tecnologia apresentada pelos aparelhos LED promete maior tempo de vida útil, não gerar aquecimento e produzir luz específica para a ativação da camforoquinona. No entanto, ainda são necessários estudos complementares para se conhecer a real efetividade destes aparelhos na polimerização dos materiais. Proposta: Neste trabalho foi verificada a microdureza de 4 cores (B-0,5, B-1, B-2 e B-3) da resina composta Filtek Z-250 (3M ESPE) quando polimerizadas com 4 fontes de luz, sendo uma halógena (Ultralux - Dabi Atlante) e três LED (Ultraled - Dabi Atlante, Ultrablue – DMC e Elipar Freelight – 3M ESPE). Métodos: Os 192 corpos-de-prova foram distribuídos em 16 grupos e os materiais foram inseridos em único incremento em matriz cilíndrica de 4mm X 4mm, sendo polimerizados pelo tempo preconizado pelo fabricante. Em seguida, foram submetidos ao teste de microdureza na superfície superior e inferior dos cilindros. Resultados: Os valores de dureza obtidos foram submetidos à análise de variância e ao teste de Tukey ao nível de 5%. Foi observado que a dureza dos corpos-de-prova variou conforme a cor do material e aparelhos utilizados. O aparelho LED que emite maior intensidade luminosa proporcionou a obtenção dos maiores valores de dureza, com o croma B-0,5 possibilitando a melhor polimerização. Por outro lado aparelhos com baixa intensidade luminosa foram os menos efetivos. Também foi observado que a região do fundo dos corpos-de-prova foi mais sensível à mudança das cores. Conclusão: Intensidade de luz dos fotopolimerizadores LED é fundamental para seu bom funcionamento, principalmente quando empregadas resinas com croma mais acentuado.

Unitermos: Microdureza; Fotopolimerizadores; Resinas compostas; CORES
INTRODUCTION

The use of composite resins has appeared in Dentistry as a response to the expectations to achieve a material that might fulfill the requirements of the oral environment and also allow achievement of restorations with proper function and especially esthetics.

Light cured composite resins offer several advantages compared to early restorative systems, and their curing depends on application of light on their surface.

Curing depth is often considered a primary factor for clinical success of composite resin restorations, since it directly affects the physical properties of materials and longevity of restorations.

The factors that may affect the curing of resin materials according to the literature include those directly related to the restorative material, including composite resin shade, amount of photoinitiators, organic and filler matrices. Similarly, light curing units also play a fundamental role for proper curing, especially concerning the period of exposure and general status of the equipment.

Therefore, in an attempt to optimize the utilization of light cured composites, manufacturers of light curing units have developed different curing systems, including those with soft start mechanism, which gradually increase light intensity, and those that emit a constant light intensity higher with a wider light spectrum. The null hypothesis to be tested was that either the shade composite resins or curing equipment would not interfere with the microhardness values.

MATERIALS AND METHODS

A total of 192 specimens were fabricated, which were distributed into 16 study groups. Specimens were fabricated with aid of acrylic cylindrical templates with a central perforation measuring 4mm in diameter and 4mm in height.

For fabrication of specimens, templates were positioned on a glass slab and completely filled in a single increment, with some excess, with the composite resin Filtek Z-250 (3M ESPE) of different shades (B-0.5, B-1, B-2 and B-3). Then, a polyester strip (3M ESPE) and another glass slab were positioned on composite resin, with application of force against the composite resin template. After 10 seconds, the top glass slab was removed, the polyester strip was kept in position and each specimen was submitted to the light emitted by the light curing units for 20 seconds, as recommended by the manufacturers. Specimens fabricated with the B-0.5 shade were light cured for 30 seconds, as recommended by the manufacturer for this shade.

Light curing units employed were the Ultraled unit (Dabi-Atlante), with 7 LEDs and light intensity of 200mW/cm²; Ultralux unit (DMC), with 19 LEDs and 400mW/cm²; Elipar Freelight unit (3M – ESPE), with 19 LEDs and 400mW/cm²; and Ultralux halogen light unit (Dabi Atlante) with 380mW/cm². All units were measured with radiometer cure Demetron Ultralux and were connected to a voltage stabilizer Revolution II (SOM) to allow maintenance of their power.

Then, templates filled with composite resin were labeled and marked on the top surface for identification of the region closest to the light source. Thereafter, specimens were cleaned with a detergent solution in ultrasound, Branson 2210, for 10 minutes, to remove debris occasionally accumulated during handling of specimens. For achievement of a surface with no staining, they were rinsed with water spray and dried with absorbent paper.

Surface microhardness of specimens was measured with HMU-2000 Shimadzu, with utilization of a Knoop indenter of 20g for 5s. This way, 3 indents were performed on top of different light curing systems available in dental market.

Moreover, composite resins currently available are highly complex and technically sophisticated materials. Therefore, to avoid selection of a certain product by the subjective preference of the operator, it is important to understand its physical and mechanical properties, as well as its performance after utilization of different light curing units.
surface and further 3 on bottom surface, which was more
distant from the light source.

Considering that each of the 16 study groups had 12
specimens that received 3 indents, original data comprised
576 microhardness values for each surface. Statistical
analysis was performed by calculation of mean values of 3
measurements performed for each surface, adding up to 192
independent data analyzed for the top surfaces and 192 for
the bottom surfaces.

Results were submitted to analysis of variance; whenever
a significant difference was found, Tukey test at the 5%
level was applied. The software employed was the SAS
System, v. 8.2.

RESULTS

Table 1 presents original microhardness means and
standard deviation of each study group with regard to the
top and bottom aspects of specimens. Analysis of both
surfaces with regard to different light curing units indicated
a statistically significant difference for all study groups;
Elipar Freelight unit (3M-ESPE) provided highest values of
surface hardness, regardless of the composite shade. The
lowest values were achieved with the Ultrablue unit (DMC),
whereas the Ultralux (Dabi Atlante) and Ultraled units (Dabi
Atlante), respectively, presented intermediate results
(Tables 2).

However, when the composite resin shades were
considered at the top surfaces, groups of B-0.5 shade
presented highest hardness values, whereas other shades
presented similar results. On the other hand, for the bottom
surfaces, all had a significant effect on the efficacy of the
units. Therefore, groups of specimens of B-0.5 shade
presented the highest means, followed by shades B-1, B-2
and B-3, respectively (Table 3).

DISCUSSION

Currently, there has been considerable emphasis on the
concentration of photoinitiators and wavelength employed
to cure resin materials, since they are in charge of conversion
of monomers into resin polymers, which determine the curing
of resin material. It is known that concentration of
camphorquinone varies between materials and may be
altered according to shade and translucency of the material9.
Thus, curing of resin materials has been subject of several
studies with different methodologies 4,5,6. These include
microhardness test, which is one of the most often employed
methods and is able to provide reliable results and
reproducibility to the study.

According to Shortall and Harrington26 (1996), intrinsic
characteristics of each material, as composition, hue and
shade, may interfere with the curing depth; an appliance
able to transmit adequate light intensity with correct
wavelength is required to provide good results15.

With regard to the appliances analyzed in the present
study, halogen light unit is the most widely employed and,
because it works in a wider light spectrum, besides curing
the restorative material, it may also heat the tooth and
composite resin during the process23. These appliances
usually work in wavelengths of 400nm to 700nm; however,
only wavelength nearly 470nm is strongly absorbed by
photoinitiator (camphorquinone)21.

Period of exposure also plays an important role in the
curing process, since the surface hardness of composite
resin is significantly increased when exposed for longer
periods10,15,26. Moreover, Caughman, et al.5 (1995) and Feilzer,
et al.7 (1995) also agree that light intensity, wavelength and
time of exposure are critical variables for achievement of
maximum curing of composite resins.

Considering these observations, analysis of
microhardness values achieved i.e. on the top revealed that
Elipar Freelight provided the best outcomes. This may be
related to the wavelength emitted by this unit, which
according to its manufacturer coincides with the maximum
absorption of camphorquinone, explaining its better
performance compared to halogen light units. Compared to
other LED units tested, Elipar Freelight unit probably was
more successful because of the higher light intensity emitted.
Within this context, according to Vieira, et al.34 (1999) and
Briso4 (2003), light emission in low intensity yields
inadequate light curing of composite resins, even if the time
recommended by the manufacturers is followed, and may
negatively influence physical properties and clinical
performance of these materials.

| Group | Mean | SD | Mean | SD |
|-------|------|----|------|----|
| I     | 59.9 | 2.78 | 40.8 | 2.03 |
| II    | 57.4 | 2.39 | 40.0 | 1.80 |
| III   | 58.4 | 1.57 | 39.8 | 0.70 |
| IV    | 58.0 | 1.83 | 37.4 | 1.15 |
| V     | 58.2 | 3.62 | 30.7 | 1.38 |
| VI    | 55.2 | 3.64 | 28.6 | 1.46 |
| VII   | 52.5 | 3.41 | 28.1 | 1.29 |
| VIII  | 51.9 | 2.45 | 27.2 | 1.75 |
| IX    | 54.2 | 1.92 | 32.1 | 0.62 |
| X     | 46.6 | 1.15 | 29.4 | 1.15 |
| XI    | 43.9 | 2.07 | 26.7 | 2.52 |
| XII   | 44.5 | 2.30 | 22.7 | 1.64 |
| XIII  | 60.6 | 1.39 | 42.8 | 1.16 |
| XIV   | 60.2 | 3.27 | 42.2 | 1.52 |
| XV    | 61.8 | 1.95 | 40.4 | 0.89 |
| XVI   | 61.6 | 1.58 | 41.4 | 0.98 |
Similarly, Ultralux unit presented better performance than Ultraled and Ultrablue units because of higher light intensity. The lower mean hardness values found for Ultraled and Ultrablue units, which are also LED units, are assigned to lower light intensity emitted and improper wavelength for curing composite resins employed. Frentzen, et al.9 (2001) compared a halogen light unit and a LED unit and reported that LED unit achieved higher hardness values; however, authors did not mention the light intensity emitted by the units, which impairs comparison with the present results.

Studies as that conducted by Pereira, et al.20 (2001) corroborate the present findings, concluding that units emitting higher light intensities have a stronger ability of curing and thereby allow achievement of higher hardness values. These aspects may also be taken into account for analysis of the Ultrablue unit, which was less effective than all other units tested.

Bosquiroli3 (2003) highlighted that resins may have different photoinitiators, and thus the emission spectrum of the equipment may be an important factor for the final properties of restorations. According to the author, the energy required for each composite should be indicated on the label, and similarly the light curing units should indicate the light intensity emitted and corresponding wavelength. These observations are extremely relevant for LED units applied on materials containing camphorquinone as photoinitiator. However, other photoinitiators require energy at other wavelengths and in these cases some units currently available will not effectively cure these materials32.

When the influence of shade on microhardness is individually considered, the results demonstrate that shade B-0.5 presented higher values than other shades. This is primarily related to the period of exposure suggested by manufacturer, which is 10 seconds more than recommended for shades B-1, B-2 and B-3. According to Baharav, et al.1 (1997) and Pereira, et al.19 (2000), the time of exposure to light is the most significant aspect influencing higher hardness values and consequently greater curing depth.

There was also significant reduction in microhardness on the bottom aspect of specimens in all study groups. Despite of that, in general the bottom aspect presented the same tendency observed at the top surface, i.e. units with higher light intensities (Elipar Freelight and Ultralux, respectively), were better than the others (Ultraled and Ultrablue), with a statistically significant difference in the performance of all units. It should be highlighted that low light intensities may only cure composite superficially, therefore impairing the clinical performance of restorations and giving the false impression that the material is well cured1. This information was demonstrated by the observation that, on the bottom surface of specimens, the composite shade influenced the performance of units. Thus, on the bottom surface, shade B-0.5 provided higher hardness values, followed by resins B-1, B-2 and B-3, respectively. This was probably due to the distance from light source, as well as because the curing depth is inversely proportional to hue value. Therefore, darker materials possibly impair light penetration into the deepest regions of specimens, as also observed by Tanoue et al.29 (2001). Considering the means achieved by the groups, this effect seems to be more significant in specimens submitted to units that emit lower light intensities (G-VIII and G-XII). This was also noticed by Ferracane, et al.8 (1997), who related the curing depth of different composite resins to

| Light source | Manufacturer | Top Mean | Decision | Bottom Mean | Decision |
|--------------|--------------|----------|----------|-------------|----------|
| Elipar Freelight | 3M-ESPE       | 61.0      | A        | 41.7        | A        |
| Ultralux      | Dabi Atlante  | 58.4      | B        | 40.0        | B        |
| Ultraled      | Dabi Atlante  | 54.5      | C        | 28.7        | C        |
| Ultrablue     | DMC           | 47.3      | D        | 27.7        | D        |

DMS (top) = 0.0235          DMS (bottom)= 0.0242

| Shade | Top Mean | Decision | Bottom Mean | Decision |
|-------|----------|----------|-------------|----------|
| B-0.5 | 58.2     | A        | 37.1        | A        |
| B-1   | 54.8     | B        | 35.1        | B        |
| B-2   | 54.1     | B        | 33.8        | C        |
| B-3   | 53.9     | B        | 32.2        | D        |

DMS (top) = 0.0235          DMS (bottom)= 0.0242
shade and translucency of materials, concluding that lighter shades allow greater curing depth. In fact, the present results are in agreement with the findings of Cook and Standish\(^4\) (1983) and Kanca III\(^{13}\) (1986) who stated that pigments employed to provide shades to restorative materials may absorb the light passing through the resin and impair curing. These pigments probably act as selective filters for certain light wavelengths. Studies conducted by Pollack and Lewis\(^{22}\) (1981), Thirta, et al.\(^{30}\) (1982), Cook and Standish\(^6\) (1983) and Swartz, et al.\(^{27}\) (1983), also reveal that light cured composite resins of dark shades require longer periods of exposure, and curing in thinner layers is recommended to allow higher hardness values.

However, despite the present considerations, it should be highlighted that Lohbauer, et al.\(^{16}\) (2005) tested several photoinitiator equipments and stated that conventional halogen light units allow less loss of mechanical properties of dental composites, even though LED units have been presenting encouraging outcomes when employed with compatible resin materials inserted with proper thickness\(^{12,18,31,33}\).

Thus, it seems evident that selection of light curing unit should be considered an important step to conduct clinical work with resin materials. It should also be mentioned that many types of units are introduced in the market every year, whose manufacturers state their proved efficiency, low cost and easy maintenance. However, professionals should base their decisions in well-designed scientific studies, besides searching for constant update, not being limited to reading folders and technical profiles supplied by manufacturers and/or representatives. These aspects demonstrate that correct selection should be based on impartial studies and materials introduced in the market may not have been adequately tested for utilization in the dental clinic.

**CONCLUSIONS**

On the basis of results achieved, the following could be concluded:

- In both LED and halogen light units, the microhardness values ranged according to the shade of resin and appliances employed;
- Shade was inversely proportional to the surface hardness of resin, with the highest values observed for shade B-0.5;
- LED units with low light intensity provided lower hardness values than high intensity units;
- Aspects distant from the light source were more sensitive to changes in shades;
- The emission of light at a specific wavelength for activation of camphorquinone by a unit did not lead to successful curing of the materials investigated.

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