Original Research

The effects of Exposure Times and Light Curing Sources on Surface Micro-Hardness of a Resin Modified Glass Ionomer

Iman Parisay[1], Zahra Bahrololomi[2], Maryam Ghafournia[3], Ali-Asghar Solaimani[4], Alireza Boruziniat[5]

[1] Department of Pediatric Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[2] Department of Pediatric Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[3] Department of Pediatric Dentistry, Esfahan University of Medical Sciences, Esfahan, Iran
[4] Department of Pediatric Dentistry, International Branch of Tehran University of Medical Sciences, Tehran, Iran
[5] Restorative Dentistry, Dental Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Received 19 December 2013 and Accepted 12 March 2014

Abstract

Introduction: The aim of this study was to evaluate the influence of different light curing systems and curing times on the micro-hardness of a resin modified glass ionomer. **Methods:** Forty two samples of Resin Modified Glass Ionomer (RMGI) were prepared using stainless steel cylindrical mold (8 × 2 mm) and randomly divided into six groups of seven. Three groups were cured with a Quartz Tungsten Halogen (QTH) light cure unit and the other three groups were polymerized with LED unit for 20, 30 and 40 seconds. All samples were stored in distilled water for 24 hours. The micro-hardness was measured on the top and bottom surfaces of the samples by Vickers hardness tester. Data were analyzed by two–way ANOVA and Tukey's post-hoc tests. **Results:** Two-way ANOVA showed that QTH light-cure unit had higher percentage in depth of cure than LED light-curing unit in both surfaces; whereas, the application time has no significant effect on it. There was no interaction between two variables. In both light-curing groups, the values of top and bottom surfaces micro-hardness were increased as the application time increased, but there was not any statistically significant difference among these groups except for 40-second group of LED light-curing unit which was significantly higher than 20-second and 30-second groups ($P<0.05$). The micro-hardness value of QTH light-curing unit was higher than LED light-curing unit. **Conclusion:** The application of QTH light-curing unit for at least 20 seconds produces sufficient micro-hardness and depth of cure of RMGI.

Key words: Glass ionomer, light curing unit, micro-hardness.

Parisay I, Bahrololomi Z, Ghafournia M, Solaimani AA, Boruziniat AR. The effects of Exposure Times and Light Curing Sources on Surface Micro-Hardness of a Resin Modified Glass Ionomer. J Dent Mater Tech 2014; 3(2): 77-81.

Introduction

In the recent years the popularity of tooth-colored restorative materials has promoted a rapidly increasing use of them. Resin modified glass ionomer materials (RMGIs) exhibit improved mechanical and physical properties and better handling characteristics than conventional glass ionomer. These materials are preferred to use in primary teeth or non-stress bearing cavities in permanent teeth especially in high risk patient (1).

RMGIs contain polyacids modified with HEMA chains which can be polymerized with light cure, so RMGIs set by at least 2 mechanisms: acid-base reaction and light-polymerization (2).

The degree of polymerization of resin-based dental materials influences their mechanical properties, solubility, dimensional stability, color change biocompatibility and success rate of these restorations (3,4). Several factors may affect on degree of polymerization including shade, thickness and composition of materials, content, shape and size of filler. Also light intensity, wave length, exposure duration, size, location and orientation of the tip of the source may change the degree of conversion (5).

Four types of polymerization sources have been developed and applied: Quartz Tungsten Halogen lamps (QTH), light Emitting Diode units (LED), plasma–arc lamps and argon – ion lasers (6,7).

QTH light-curing units are the most commonly devices for the polymerization of resin based dental materials in daily clinical practice (6). This low cost technology device has a broad emission spectrum allowing the polymerization of all kind of available resin composite materials (7). However, they have several drawbacks. Their efficiency in converting electronic energy into the visible light is estimated to be low (10%) and up to 70% of their energy is transformed to heat (8). Moreover, the light filters degrade with time due to the high operating temperature and proximity to the halogen bulb, so the irradiance declines overtime which could lead to inadequate polymerization of resin (9,10).

With the objective of overcoming these limitations inherent to halogen lamps, the first light emitting diode (LED) devices were introduced into the dental market in 2001 (11).

The performance of LED devices don't significantly decrease over time as do QTH units (12).LED they are typically smaller, lighter in weight and they have ability to operate in a cordless fashion. Also, they doesn't induce the infra-red, so cooling fans are not required. The main disadvantage of these devices includes producing light within a narrow spectral range which might be not suitable for polymerization of some type of resin composites (11-14).

The degree of polymerization of resin composites may be evaluated by direct or indirect methods. The direct methods such as infrared-spectroscopy and laser Raman are not commonly used, because they are complex, time consuming and expensive (15,16). The indirect methods including scraping, visual inspection and the surface hardness evaluation are more commonly used (16).

The surface hardness test has vastly been used in studies, because it may be a proper indicator of the degree of conversion (17).

The surface hardness can be measured either, along the side of specimens, which will indicate gradual change in depth of cure, or on the upper and lower surfaces of disc shaped specimens with a given thickness. The latter is used to measure the relative hardness, which is also considered a good indicator of degree of conversion.

The aim of this study was to evaluate the surface hardness of RMGI with QTH and LED light-curing unit at 20, 30 or 40 seconds of polymerization time. The null hypothesis was that neither type of light-cure unit nor application time has effect on micro-hardness and percentage of depth of cure.

Materials and Methods

Forty two cylindrical specimens of RMGI (8×2 mm) (Fuji II LC, GC Corporation, Tokyo, Japan) were prepared according to the manufacturer's instruction in steel ring molds. The mold containing RMGI was held between two glass slides. For the purpose of surface standardization, the glasses have covered with a transparent Mylar strip (Mylar, DuPont, Wilmington, Del., USA) and they gently pressed together to remove excess RMGI. The specimens randomly divided into two groups according to light-curing units (QTH (Arialux 13298, Tehran, Iran) and LED (Starlight Pro, Mectron, Italy)) were applied.

Prior to the light polymerization, the light output for QTH and LED were measured by QTH radiometer (Litex 682, Dentamerica, Taiwan) and LED radiometer (Apoza, Taiwan) respectively. They were measured 3 times with a time interval of 1 minute and 40 seconds. The average intensity of light was recorded for QTH and LED were 600 mw/cm^2 and 700 mw/cm^2 respectively.

Each group randomly divided, by computer, into three subgroups of seven in relation to polymerization time used (20, 30, 40 seconds).

The conventional mode was used for both devices and the light-guide was in contact with the cover glass during the light polymerization process. The distance between the light source and sample was standardized by using a 1mm glass slide.

After curing, the top surface of specimens were marked by water-proof pen and then all the samples were stored in distilled water for 24 hours at 37°C in a dark place.

Micro-hardness measurements were obtained by using a Vickers Hardness Testing Machine (Mh2012, Koopa Pazhoohesh, Tehran, Iran).Three indentations were randomly made on the top and bottom of each specimen by applying a 50gr load for 20 seconds, and a mean value for each surface were measured.

The hardness ratio was calculated by dividing the bottom hardness value by the top hardness value, and by multiplying this ratio to 100; percentage of depth of cure was calculated. All data were analyzed statistically by Two-way ANOVA, Tukey's post-hoc test (α = 0.05). Analysis was conducted with Statistical package for the social science SPSS (version 11.5 SPSS Inc, Chicago, IL, USA)

Results

The mean values of micro-hardness and hardness ratio for each group are presented in Table 1. Two-way ANOVA showed that type of light-curing unit has a statistically significant effect on percentage of depth of cure. QTH light-cure unit has significantly higher percentage of depth of cure than LED light-curing unit (P= 0.00). Whereas, the application time has no significant effect on it (P= 0.86) Also, there was no interaction between two variables (P= 0.07)

In both light-curing groups, the values of top and bottom surfaces micro-hardness were increased as the application time increased, but there was not any statistically significant difference among these groups except for 40-second group of LED light-curing unit which was significantly higher than 20-second group (P< 0.001) and 30-second group (P= 0.035).

Discussion

The results of current study partially rejected the null hypothesis. In present study, increasing exposure time in QTH groups led to increasing both top and bottom surface micro-hardness values but there were no significance differences between 20, 30 and 40 seconds groups. Therefore, it seems that 20 seconds polymerization with QTH light-curing unit is sufficient for polymerization of RMGI .It should be considered that RMGI is widely used for restoration of primary teeth and time is critical factor in pediatric dentistry. The hardness of light polymerized dental materials is dependent on the polymerization conditions, the light intensity and the exposure duration.

Adequate polymerization is a crucial factor in obtaining the optimal physical performance of resin based materials (18). The efficacy of light-cure units in polymerization of RMGI was assessed by evaluation of micro-hardness in top and bottom surfaces of samples.

In this study micro-hardness of top surface was higher than bottom surface in all experimental groups. These results are similar to results of other studies have done by Dunn and Bush (19) and Cavalcante et al. (20). One possible explanation for this difference is that, as light passes through the bulk of the RMGI, light intensity is reduced due to light scattering by the bulk of material.

There are many variables which can affect the amount of light energy received at the top and bottom of restorations such as design of the light guide, power density, exposure duration, shade, opacity, thickness and composition of the materials (2,21,22). Exposure duration may be one of the factors which can change it in clinical situations.

In this study top and bottom surface micro-hardness values for 40-second LED group were significantly higher than 20- and 30-second LED group, but between 20 and 30 seconds LED groups there was not any statistically significant differences. LED light-curing unit could achieve 80% proper curing depth just with 40 seconds polymerization duration. By contrast, Alpoz et al. (14) demonstrated found that surface hardness of RMGIC did not change with the different exposure time with LED and my affect by characteristics inherent to the specific material being cured.

Table 1. Mean micro-hardness values (Std Dev) and hardness ratio for QTH, LED groups

		Fuji II LC			
device	time	Surface hardness	Bottom hardness	Hardness ratio	Curing depth percentage
QTH (Arialux)	20	43.7 (3.8)	39.6 (4)	0.9	90
	30	45.3 (5.1)	41.5 (2.7)	0.92	92
	40	47.9 (2.6)	44.8 (3.4)	0.93	93
LED (Starlight pro)	20	35.1 (10)	24.2 (7.4)	0.69	69
	30	41.7 (7.3)	30.2 (3.6)	0.73	73
	40	47.5 (7.7)	38.5 (6.2)	0.81	81

Finally, it was found that, independent of exposure time, the depth of cure for QTH curing units was significantly higher than LED curing unit (P<0.001). This result is similar to result of ozturk's research (19). Alpoz et al. (14) showed low intensity LED device with same exposure time of 40-second is similar or more efficient on mechanical properties of resin based materials such as composite and RMGI in comparison with a high intensity halogen light unit. By Contrast, Bala et al. (23) found that the composite cured with LED for 40 seconds had higher surface hardness than halogen cured composite. Also, some studies indicated that the newer generation of LED devices can be more efficient than halogen units (15, 24). In the current study, the light intensity of halogen device was less than LED unit but, it was more efficient on surface hardness of RMGI. RMGI materials have dual cure polymerization so; the heat produced during curing with halogen device may increase the rate of self-cure polymerization of RMGI and surface hardness. This may be an explanation for better result of halogen device.

It should be considered that although the intensity of light used for curing the RMGI has certain effect on degree of conversion and surface hardness, it is difficult to use QTH and LED light curing units which have same intensity because of manufacturer's set-up of these devices. In previous studies, LED and QTH light units with different intensities were used for evaluation of mechanical properties of various resin based materials (14,25).

Conclusion

On the basis of these results, it was concluded that:

1. The RMGI samples cured by QTH light-curing unit had higher micro-hardness than ones cured by LED.

2. The increase of exposure time could not significantly increase the micro-hardness and depth of cure except for 40 seconds in LED group.

Due to limitation of this study only one type of RMGI was evaluated. So, the results of this study may not attribute to all RMGI. Furthermore, the authors suggested evaluating the effect of different curing modes (pulse, ramp, etc) on the micro-hardness of RMGI.

Acknowledgements

We acknowledge the financial support of the vice president of the Research Center of Yazd University of Medical Sciences. The results presented in this study have been taken from a student thesis (No: 364).

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Corresponding Author:
Alireza Boruziniat
Faculty of Dentistry and Dental Research Center
Vakilabad Blvd, Mashhad, Iran
P.O. Box: 91735-984
Tel: +98 511 8829501
Fax: +98 511 8829500
E-mail: Borouziniata@mums.ac.ir