



LIGHT-EMITTING DIODE *versus* HALOGEN LIGHT CURING OF ORTHODONTIC BRACKETS: a clinical study of bond failure

Colagem de brackets ortodônticos: polimerização da resina por meio de diodos emissores de luz versus luz alógena: estudo clínico de falhas de adesão

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Abstract

OBJECTIVE: The purpose of this study was to evaluate the clinical performance of brackets cured with two light-curing units. **MATERIALS AND METHODS:** Forty female patients (between 12-16 years old) who required fixed appliances were included in this study. Based on the characteristics of their lower arches, study participants were divided into two groups, A and B. In group A, the composites were cured on the right side by Ultralume LED2TM and on the left side by a conventional halogen unit. In group B, the sequence was reversed. A total of 160 brackets were bonded. After 12 months, bond failure rate was evaluated. **RESULTS:** We found that 18 brackets in the halogen group and 13 brackets in the LED group were debonded. No statistically significant differences were found in total bond failure rate and no enamel damage was clinically detected for either technique. **CONCLUSION:** These results suggest that LED dose curing does not result in more bond failure when compared with conventional halogen light curing.

Keywords: Bond failure. Orthodontic brackets. Halogen light. Light-emitting diode.

Resumo

OBJETIVO: O objetivo deste estudo foi avaliar o desempenho clínico de brackets colados utilizando-se de duas unidades de polimerização. **MATERIAL E MÉTODO:** quarenta pacientes adolescentes com indicação de tratamento ortodôntico fixo foram incluídos no trabalho, divididos em dois grupos, A e B. No grupo A, o composto foi polimerizado no lado direito com Ultralume LED 2TM e no lado esquerdo com luz halógena convencional. No grupo B, a sequência foi invertida.

Um total de 160 brackets foram colados. Após 12 meses de tratamento, avaliou-se a taxa de falhas de colagem. **RESULTADOS:** 18 brackets no grupo halógeno e 13 no grupo LED sofreram descolamento. Não houve diferença estatisticamente significativa na taxa total de falhas e não foram observados danos ao esmalte em ambas as técnicas. **CONCLUSÃO:** Estes resultados sugerem que a fotopolimerização com LED não resulta em maiores falhas de adesão quando comparadas com a luz halógena convencional.

Palavras-chave: Falhas de colagem. Ortodontia. LED. Luz halógena.

INTRODUCTION

Visible light curing units are an important part of modern adhesive dentistry. In orthodontics, visible light curing units are mainly used to bond orthodontic brackets to teeth. Bonding with light-activated systems is popular because the extended working time allows for precise bracket placement. Once the bracket is positioned in the desired location, a rapid command set is accomplished through photoactivation (1). Currently, most sources of visible blue light applied in dentistry use tungsten filament halogen lamps that incorporate a blue filter to produce light of 400-500 nm. Halogen-mediated light conversion is inherently inefficient (2). The main problems encountered with conventional halogen units are the degradation of the lamp, the filter, and the reflector, leading to reduced curing effectiveness (3). Therefore conventional halogen units have a limited lifetime of 100 hours. Filters can undergo blistering and reflectors discolor (3, 4). The prolonged curing time when using halogen bulbs is uncomfortable for the patient, impractical with children, and inconvenient for the clinician. Various attempts have been made to enhance the speed of the light-curing process by using a larger light guide or laser devices (5).

The most common light source used in dentistry is the quartz-tungsten halogen machine (QTH). Since 1970, halogen light cures were the tools selected for curing with visible light. This apparatus has several limitations (6, 7). Only 1% of the total energy input is converted into light, with the remaining energy generated as heat. Other disadvantages include the short life of halogen bulbs and noisy cooling fan (8). A critical factor in the production of optimal cohesive composite resin strength is the amount of polymerization. The degree of polymerization is directly related to the amount of total energy that the resin absorbs. Total light energy

is related to the intensity of the light and the duration of exposure (9). Greater total light energy generally results in resin with increased fracture toughness and greater flexural strength, which translates into brackets with greater bond strength (9). Light-emitting diodes (LED) are reported to produce light of greater intensity, which could mean reduced curing time and greater bond strength (10).

Mills and Nakamuna introduced the LED apparatus as a polymerizing source. They used gallium nitride semi-conducting sheets to produce blue light. The wavelength of outgoing light was 450-490 nm, which is in accordance with the light-absorbing limit of Kamfor Kinon. Unlike halogens, gallium nitride semi-conducting sheets do not require filters. Reports have described a long shelf-life of 10,000 hours (11, 12). LED are more efficient converters of electrical power into visible blue light and do not generate the great amount of heat associated with halogen lamps (4). Much of the spectral radiant intensity for most blue LEDs lies in the 468-nm region, which is also the optimum range of absorption for the photoinitiator. Therefore, LEDs produce an almost ideal light bandwidth.

To our knowledge, the curing efficiency of LED devices has not been fully evaluated in orthodontic bracket bonding. Previous in vitro investigations evaluating the bond strength of brackets cured with LED reported no significant differences after comparisons with brackets cured with conventional halogen lamps (13-15). However, studies conducted under ideal laboratory conditions do not describe how materials might perform in the oral cavity.

Clinically, intraoral contamination, moisture, temperature and other factors such as masticatory forces and orthodontic loading can influence bond strength (10). Some clinical trials reported no significant differences between LED and halogen (10, 16).

This study was undertaken to evaluate the efficiency of LED for bonding brackets as compared with tungsten filament halogen bulbs on a clinical basis. Their curing efficiencies and bond strengths were evaluated *in vivo*, based on the number of bond failures.

MATERIALS AND METHODS

Forty female patients treated with fixed appliances were included in this study. The ages of our patients were between 12-16 years. With the split-mouth design, each patient's mouth was divided into two quadrants. In group A, the mandibular right quadrant was cured by LED (Ultralume LED2™) and the mandibular left quadrant was cured by a conventional halogen unit (Astralis 7™). In group B, the right mandibular quadrant was cured by conventional halogen and the left mandibular quadrant was cured by LED.

Bonding, follow-up, and assessment of bond strength were conducted by one operator. An effort was made to bond the same number of brackets on each side of each arch in each patient. We also attempted to keep similar numbers of brackets bonded for both of the curing techniques used. In order to eliminate any bias, we alternated the split-mouth design from patient to patient. All teeth were isolated with cheek retractors and cleaned with a mix of water and fluoride-free pumice, with a rubber polishing cup and a low-speed handpiece. The teeth were rinsed, dried with an oil-free air syringe, and etched with 37% phosphoric acid for 30 seconds. After thorough washing, teeth were completely dried with an oil-free syringe. Then, stainless steel brackets with a 0.018-in slot (Dentaurum™, Germany) were bonded to the premolars with Resilience™ composite resin, according to the manufacturer's guidelines. After applying primer, a small amount of composite resin was placed on the mesh pad of the bracket. The bracket was positioned on the labial surface of the tooth with sufficient pressure to squeeze out excess adhesive, which was removed from the margins of the bracket base with an explorer prior to polymerization. The bonding technique was standardized. When the operator was satisfied with the bracket position, the

contralateral quadrants were cured with one of the two curing techniques.

The composites in the halogen group were polymerized by 40 seconds of exposure to a conventional halogen visible light source which generated light with a wavelength of 470 nm. Wavelength was determined to be in the 470-nm range with a radiometer. The light source was aimed at the mesial surface of the bracket base for half the total curing time. The procedure was then repeated for the distal surface of the bracket. In the LED group, adhesive was cured for 20 seconds. In a laboratory study on LEDs, Bishara et al. recommended a minimum exposure of 20 seconds per bracket (14). All brackets were bonded during one appointment by the same operator, and the quadrants were reversed from one patient to another. The patients were unaware of which light was used on which side of their mouths. Active wires were placed immediately after curing the last bracket placed. The initial arch wire in all patients was a 0.014-in nickel-titanium wire. Both patient groups were monitored for 12 months. If a bond failed, we recorded which tooth the failure occurred in, as well as the type of light used. All patients received the same instructions and were seen at 3-4 week intervals. They were instructed to brush with a manual toothbrush, according to the modified Bass method, twice daily, with toothpaste. The patients were asked to report or write down the date of any bracket bond failures. The duration of treatment for each breakage was calculated as the difference between the date the breakage was noted and the date of initial bonding. However, bonded teeth that were rebonded after failure were not included in the success analysis, because replacing a bracket could affect its bond strength. Statistical analysis was performed with SPSS 10.5 software. Intervention outcomes in these two groups were compared with Chi-SQUARE and FISHER 's exact tests.

RESULTS

The number of bond failures was greater in the halogen group (Table 1). The groups were separately and completely evaluated (Tables 2, 3, 4). No enamel damage was clinically detected.

TABLE 1 - Bracket comparison between halogen and LED lights

p-value	Failures (%)	Failures (n)	Brackets (n)	Type of Light
0.212	22.5%	18	80	Halogen
	16.3%	13	80	LED
	19.4%	31	160	Total

TABLE 2 - Bracket comparison between halogen and LED lights

p-value	Failures (%)	Failures (n)	Brackets (n)	Type of Light
0.395	20%	8	40	Group A
	25%	10	40	Group B
	22,5%	18	80	Total

Group A: Right side was cured by LED and left side was cured by halogen.
Group B: Right side was cured by halogen and left side was cured by LED.

TABLE 3 - Bond failure rate in LED groups

p-value	Failures (%)	Failures (n)	Brackets (n)	Type of Light
0.273	20%	8	40	Group A
	12,5%	5	40	Group B

Group A: Right side was cured by LED and left side was cured by halogen.
Group B: Right side was cured by halogen and left side was cured by LED.

TABLE 4 - Comparison between left and right sides of the mandible

p-value	Failures (%)	Failures (n)	Brackets (n)	Type of Light
0.212	10	8	80	Right premolars
	8	5	80	Left premolars
	18	13	160	Total

DISCUSSION

The bond failure rate of brackets cured with conventional halogen light was not statistically different from that of brackets cured with LED light. We did not evaluate age, sex, or malocclusion type because previous studies found no significant differences for age, malocclusion type or sex (17-20).

Few clinical studies have been conducted to evaluate the clinical performance of brackets bonded with a composite resin as compared to brackets cured with halogen or LED light. Previous laboratory studies on the bond strength of brackets cured with LED reported no statistically significant differences between conventional light and LED light (4, 13-15, 21, 22). According to laboratory reports, LEDs have better light energy (3, 4, 9, 22, 23). The energy required to generate the amount of radicals necessary for polymerization of the resin was less than the amount of energy released by the halogen light. Jandt et al. (24) and Mills et al. (4) also found that the depth of penetration of the LED was 95%, and that this method consumed less power. Dunn and Bush (2) concluded that there was good absorption of light with an LED system. Dunn et al. found no significant difference between LED and halogen apparatuses. However, halogen light resulted in more firmness than LED light, likely due to the use of a first-generation LED (25).

Cacciafesta (26) introduced a new model of LED (GC-E light) and compared it with halogen. Although LED use resulted in greater bond strength, the difference was not significant. In a study directed by Usumeze et al. (27), no significant differences were observed in bond strength between halogen and LED apparatuses, at different times of polymerization (10 s, 20 s and 40 s). Although the author observed no significant differences in bond strength for LED as compared to halogen, Silta (28) recommended using a second-generation LED.

Bishar et al. (29) reported that in the first 30 minutes after binding, LED and halogen produced similar bonds. Notably, a new LED allows the clinician to simultaneously cure 2 brackets without any effect on bond strength, so that the total time required is reduced by half (29). Swanson et al. (30) studied the shear bond strength in brackets bonded to enamel and photopolymerization by LED and QTH. The authors reported that among the apparatuses tested, the lowest bond strength resulted from use of the GC-E light for 10 and 40 seconds; the greatest bond strength resulted from use of the LED 2. These results were different from the results reported by Wendle (31) in studying both apparatuses. He reported that halogen yields stronger bonds than does LED. It is possible that these results reflect the use of powerful halogens as compared to first-generation LED units (32).

CONCLUSIONS

We observed no significant differences in total bond failure rates between brackets cured with the halogen light as compared to those cured with the LED unit. Therefore, LED can be considered an alternative to conventional light curing. LEDs significantly reduce curing time without affecting bond failure rate.

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