

## Dentine bond strength of a composite resin polymerized with conventional light and argon laser

### *Resistência de união à dentina de resina composta polimerizada com luz halógena e laser de argônio*

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**ABSTRACT:** The use of argon laser (488 nm) has been suggested as a new alternative for polymerizing adhesive materials. This study aimed to evaluate the tensile bond strength of a microfilled composite (A110, 3M) inserted by incremental technique (3 increments of 1 mm) and by single increment (3 mm) polymerized by argon laser for 10, 20 and 30 seconds and halogen light for 40 seconds. Eighty (8 groups of 10 teeth) freshly extracted bovine teeth were stored in a freezer in distilled water for one week. The crowns were cross-sectioned from the roots. Pulpectomy was performed and the pulp chambers were sealed with wax. The buccal surfaces of the teeth were ground with wet sandpaper (grains: 120, 400, and 600) to expose the surface dentin, and the teeth were then included in acrylic resin. A metal device was used to fix each sample and a black propylene matrix<sup>25</sup> (3 mm high with an internal millimetric delimitation) was used to insert the material according to the groups studied. The polymerization intervals were of 10, 20 and 30 seconds for the laser polymerization and 40 seconds for the conventional polymerization. Tensile tests were performed by a Universal Testing Machine 4442 (Instron) at a speed of 0.5 mm/min and 500 N load. According to the methodology used, the incremental technique increased bond strength values. There was no difference between the studied polymerization techniques when resin was filled in 3 increments.

**DESCRIPTORS:** Lasers; argon; Composite resins; Dentin; Tooth.

**RESUMO:** O uso do laser de argônio (488 nm) tem sido sugerido como uma nova alternativa para polimerização de materiais adesivos. Este estudo tem o objetivo de avaliar a resistência adesiva de uma resina composta micro-particulada (A110, 3M) inserida pela técnica incremental (3 incrementos de 1 mm) e de incremento único (3 mm) polimerizada com laser de argônio por 10, 20 e 30 segundos e com luz halógena por 40 segundos. Oitenta (8 grupos com 10 dentes) dentes bovinos recém-extraídos foram armazenados em geladeira, em água destilada, por uma semana. As coroas foram separadas das raízes. Foi realizada a pulpectomia, e as coroas foram seladas com cera. As faces vestibulares foram desgastadas com seqüência de lixas (120, 400 e 600) para expor a dentina superficial, e os dentes foram incluídos em resina acrílica. Foi utilizada uma mesa metálica para fixar cada espécime com a matriz de polipropileno preta (3 mm de altura com delimitação interna milimetrada) e inserir a resina de acordo com os grupos estudados. Os tempos de polimerização foram de 10, 20 e 30 segundos para a polimerização com laser e de 40 segundos para a polimerização convencional. Os testes de resistência adesiva foram realizados com a máquina universal de ensaios 4442 (Instron) com velocidade de 0,5 mm/min e carga de 500 N. De acordo com a metodologia usada, a técnica incremental aumentou os valores de resistência adesiva. Não houve diferença entre as técnicas de polimerização usadas quando a resina foi inserida em 3 incrementos.

**DESCRIPTORES:** Lasers; argônio; Resinas compostas; Dentina; Dente.

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## INTRODUCTION

Patients' demand for aesthetic restorations stimulates many investigations in order to improve composite resin restoration techniques.

Restorative dentistry is undergoing constant and fast progress in material improvement on adhesive capacity and durability. Furthermore, while searching for the improvement of resin compo-

sition, another aspect that has interested many investigators was how adhesive materials have been light-cured and the light quality used for this procedure.

Current photoactivated dental resins use a diketone initiator (camphorquinone) and a reducing agent (tertiary amine) to initiate polymerization.

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This photoinitiator system is highly sensitive to the blue region of the visible light spectrum, with activity peak around 480 nm. As halogen light sources emit a large variety of wavelengths, spectrum filters to strike out the wavelengths that are inactive for camphorquinone are necessary. The useful wave band for light-cured composite polymerization of this type of equipment is narrow. Due to this unfavorable factor of conventional apparatuses, studies on the polymerization capacity of argon laser (488 nm) have been developed to search for better results for composite resin restorations.

This study aimed to evaluate the tensile bond strength of a microfilled composite inserted by the incremental technique and by a single increment technique polymerized by argon laser for 10, 20 and 30 seconds and halogen light, for 40 seconds.

## MATERIALS AND METHODS

Eighty freshly extracted bovine teeth were stored in distilled water in a freezer for one week<sup>26</sup>. The crowns were cross-sectioned from the roots. Pulpectomy was performed and pulp chambers were sealed with wax (Horus Dentsply, Petrópolis, RJ, Brazil). Buccal surfaces of the teeth were ground with wet sandpaper (grains: 120, 400, and 600, Buehler Ltd., Lake Bluff, IL, USA) to expose the surface dentin. Teeth were included in acrylic resin and then stored in distilled water at 37°C.

The Scotchbond Multi Purpose (3M, St. Paul, USA imported by 3M do Brasil Ltda., Dental Products, Sumaré, SP, Brazil) adhesive system was applied following the manufacturer's directions. Dentin was etched with 37% phosphoric acid (3M, St. Paul, USA imported by 3M do Brasil Ltda., Dental Products, Sumaré, SP, Brazil) for 15 seconds, washed with water and dried with absorbent filter paper (Mellitta, RS, Brazil) to prevent dentin dehydration. Primer (3M, St. Paul, USA imported by 3M do Brasil Ltda., Dental Products, Sumaré, SP, Brazil) was actively applied to dentin surface and dried for 5 seconds followed by the application of the adhesive system, which was polymerized by argon laser (Accucure 3000, LaserMed, Salt Lake City, UT, USA at 200 mW power set for 5 seconds according to the manufacturer's directions or by halogen light (Degulux Soft-Start, Degussa-Hulls, Hanau, Germany) at a power density of 550 mW/cm<sup>2</sup> for 10 seconds.

A metal device (Houston Biomaterials Research Center, Dental Branch, Houston, University of Texas, USA) was used to fix each sample

**TABLE 1** - Parameters used in this study.

		Laser 10 s	Laser 20 s	Laser 30 s	Photo 40 s
A110	P (mW)	200	200	200	275
	PD (mW/cm <sup>2</sup> )	714.28	714.28	714.28	550
	E (J)	2	4	6	11
	ED (J/cm <sup>2</sup> )	7.14	14.28	21.42	22

P - power; PD - power density; E - energy; ED - energy density.

and a black propylene matrix<sup>25</sup> (University of São Paulo, SP, Brazil, 3 mm high and internal millimetric delimitation) was used to insert the material according to the groups studied.

The intervals used for laser polymerization were of 10, 20 and 30 seconds and, for conventional polymerization, 40 seconds.

The samples were stored for one week<sup>13,23</sup> in distilled water (100% relative humidity) in a black container (protected from external light) at 37°C.

The tensile tests were performed by a Universal Testing Machine 4442 (Instron, Canton, MA, USA) at a speed of 0.5 mm/min and 500 N load.

Table 1 shows all parameters used in this study.

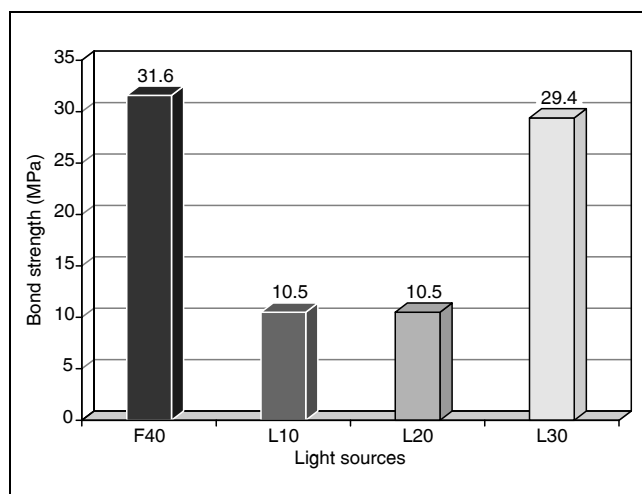
## RESULTS

### Comparison between polymerization sources with composite resin filled in a single increment

The Kruskal-Wallis test ( $H = 33.64$ ) revealed statistical difference between the studied groups. Halogen light and the 30-second laser polymerization showed the highest bond strength values and there was no statistical difference between these groups. Laser polymerizations for 10 and 20 seconds were unable to achieve acceptable adhesion. Graph 1 and Table 2 illustrate the differences detected.

### Comparison between polymerization sources with composite resin filled with the incremental technique (3 increments of 1 mm)

Results obtained with the Kruskal-Wallis test ( $H = 6.22$ ) demonstrate no statistical difference between the polymerization sources studied in this comparison.



**GRAPH 1** - Composite resin (A110) filled in one increment of 3 mm. Comparison between the curing sources. F40: halogen light for 40 s; L10: argon laser for 10 s; L20: argon laser for 20 s; L30: argon laser for 30 s.

### Comparison between the filling techniques (single increment versus 3 increments)

The influence of the filling technique on composite resin (A110, 3M) bond strength was tested. The Mann-Whitney statistical test was chosen to compare these two groups.

Polymerization by halogen light for 40 seconds ( $z = 1.2851$ ) showed the following values:  $U_1 = 33$  (one increment) and  $U_2 = 67$  (3 increments of 1 mm), resulting in no statistical difference between these groups.

argon laser polymerization for 10 seconds ( $z = -3.7796$ ) revealed statistical difference (5%) between the filling techniques. The incremental technique showed the highest bond strength. Adhesion was not observed in the single increment groups polymerized for 10 and 20 seconds with the argon laser. However, it was observed in the group polymerized by laser for 10 seconds using the incremental technique.

There was no statistical difference between the filling techniques in the 30-second laser polymerization groups ( $z = 0.1512$ ).

## DISCUSSION

In spite of being almost impossible to reproduce the clinical situations *in vitro*, laboratory tensile bond strength tests are commonly used to evaluate the efficacy of restorative systems and also to predict their clinical behavior<sup>17</sup>. Ferracane, Greener<sup>7</sup> (1986) asserted that it was possible to

**TABLE 2** - Post averages.

Sample	Post sum	Average
F40	316	31.6
L10	105	10.5
L20	105	10.5
L30	294	29.4

F40: halogen light for 40s; L10: argon laser for 10s; L20: argon laser for 20s; L30: argon laser for 30s.

correlate mechanical properties with composite resin conversion degree and presume these conversion degrees from tests that evaluated composite mechanical properties<sup>15</sup>.

There are many variables to be considered when bond strength between restorative materials and dental structure is studied.

With regard to the substratum used for adhesion tests, many authors show that there is no statistical difference between bond strength in human dentin and in bovine surface dentin<sup>14,22</sup>.

The standardization of dentin depth is another important factor to be considered. Different dentin regions present morphological and structural variations that may determine distinct adhesion mechanisms<sup>16</sup>. McCabe, Rusby<sup>13</sup> (1992) concluded that surface dentin produces higher bond strength values, probably because it is difficult for fluid resin to penetrate in deep dentin since it has more humidity.

The dentin depth was standardized according to Al-Salehi, Burke<sup>1</sup> (1997). The study conducted by Silva *et al.*<sup>23</sup> (1996) demonstrates no statistical difference in bond strength for periods of up to one week.

This study investigates the variation of polymerization sources. The type of the polymerization used may directly determine success of a restoration<sup>21</sup>.

According to Kelsey *et al.*<sup>10</sup> (1989), due to the previously mentioned peculiar characteristics of laser light, there is an optimization of the argon laser beam used in polymerization. Energy loss is reduced when compared with the halogen lamp, reducing the curing time and improving physical properties of composites, such as compressive resistance, diametral bond strength and flexural resistance. Indeed, most investigators are unanimous in affirming that argon laser improves the physical properties of the tested materials<sup>2,3,5,8</sup>.

The composite conversion degree is another characteristic that may be improved.

This study was performed using the polymerization technique with surface contact. Although other investigations demonstrate no energy loss in laser-curing within a distance between light source and resin of up to 6 mm<sup>9,11,19</sup>, in conventional light-curing, the greater the distance between light source and resin, the smaller the density power that reaches the composite surface<sup>6,18</sup>.

According to the results obtained from the comparison between the polymerization sources with the single increment of 3 mm, in the 10- and 20-second laser polymerization groups composite resin did not adhere to dentin. We could suppose that using a power set of higher intensity or increasing polymerization time could improve the cure of a microfilled composite. This type of material has lower light penetration power than hybrid composites because of light dispersion through the organic matrix<sup>24</sup>. Therefore, changing the parameters used could be more advantageous in view of the possibility of filling the resin in a single increment. Moreover, microfilled composite resins have a large amount of monomer that may be converted into polymer, consequently requiring curing parameters different from the ones used for hybrid composites polymerization.

The same comparison with the laser polymerization for 30 seconds showed the highest values and was not statistically different from the polymerization with halogen light. However, in a clinical situation, professionals should not use application parameters different from the ones recommended by the manufacturer, because this could cause damage to adjacent tissue<sup>4</sup>.

Halogen light and the argon laser for 30 seconds demonstrated no statistical difference regarding the filling technique probably because of the greater exposure time for the laser and the greater energy density of the conventional light favoring greater power of light penetration and, consequently, a deeper curing capacity<sup>12</sup>.

In the other laser groups (10 and 20 seconds), the incremental technique showed to be more effective with regard to bond strength<sup>20</sup>.

Laser polymerization of the 3 mm increment composite resin did not show any improvement in bond strength when compared to halogen lamp polymerization.

Analyzing all variables reported in this investigation, further research seems to be necessary in order to define an ideal protocol for the use of argon laser for each type of resin, bearing in mind all the advantages that this new technology can offer, as well as its limitations.

## CONCLUSIONS

1. The laser polymerization for 10 and 20 seconds in a single increment demonstrated a lower tensile bond strength compared to the 40-second polymerization with halogen light and there was no statistical difference between halogen light (40 seconds) and argon laser-curing for the 30-second interval.
2. There was no statistical difference between the curing sources for the incremental technique.
3. Incremental technique showed the highest tensile bond strength values, except for the polymerizations with halogen light and argon laser for 30 seconds, which did not show statistical difference.

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