Assessment of the Ability of Er:YAG Laser to Remove Composite Resin Restorations

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Purpose: The purpose of this study was to assess in vitro Er:YAG laser efficacy for composite resin removal, as well as the thermal alterations occurring during laser irradiation.

Materials and Methods: Cavity preparations (1.0 mm deep) in bovine teeth were restored with resin and divided into 2 groups: the control group, in which restorations were removed with a high-speed bur, and the experimental group, in which restorations were removed with Er:YAG laser at 250 mJ output energy, 80 J/cm^2 energy density, and 6 Hz pulse repetition rate. The removal time was measured and the temperature alteration was checked. After the removal, the specimens were split in the middle, and the surrounding and deep walls were analyzed to check for the presence of restorative material.

Results: The results revealed that the temperature rise during composite resin removal in both groups occurred on the substrate underneath the restoration. Although the temperature rose during composite filling removal, none of the groups presented a temperature increase higher than 5.6°C, which is considered the critical temperature increase above which there may be irreversible thermal damage to the pulp. Regarding the time for composite filling removal, it was observed that the laser group required more time than the control group for complete elimination of the material from the cavity walls.

Conclusion: Although there was a greater temperature increase during composite resin removal with Er:YAG, it did not reach the critical temperature value above which there may be irreversible thermal damage to the pulp.

Keywords: ablation, Er:YAG laser, composite resins, temperature, time, efficacy.

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Alternative methods such as air abrasion, ultrasound and laser irradiation have been proposed for adhesion, cavity preparation[1] and superficial treatment of the substrates.[2] Some positive aspects of laser use are treatment without anesthesia on children and adults,[3,4] and less discomfort during cavity preparation[5,6] due to the elimination of such factors as vibration, pressure, noise, and the patient's stress during conventional procedures with rotating instruments.

Different kinds of lasers have been employed in dentistry. Currently, the Er:YAG laser shows superior performance as regards cavity preparation in dental hard tissues,[7] showing its ability to remove enamel, dentin, and caries, with less thermal damage to the tooth, which is one of the greatest problems associated with other lasers, such as Nd:YAG and CO_2.[8,9] The Er:YAG laser causes vaporization of water and hydrated organic components of the tissues. The energy striking the dental structure during irradiation is just sufficient to vaporize water. The greatest part of this energy is spent in the ablation process and only a small fraction of it results in heating of the remaining dental structure.[10] The studies that evaluated temperature increases with the use of Er:YAG laser present great differences with respect to power settings, frequency, size, and depth of the preparations.[6,11,12] However, there is consensus on the importance of using water cooling for laser cavity preparations.[13,14]

Another use of laser is the effective removal of cements and composite resin restorations, comparable to the way enamel and sound dentin are removed.[14-16] A selective differential ablation of composite resin can be made in the case of old and unsatisfactory restorations in enamel, remains of resinous material from the flat surfaces of enamel, and after removal of orthodontic brackets or periodontic splints.[15]

The Er:YAG laser irradiation produces a photomechanical interaction mediated by water during the process of ablation of dental hard tissues. In spite of this, the removal of composite resins seems to occur with very little water-mediated mechanical action. Actually, there is direct absorption of laser energy by the resinous material, generating heat that will result in an explosive vaporization, followed by hydrodynamic ejection.[14,15]

Some studies[17,18] assessed the uses of laser for the removal of dental hard tissues, focusing mainly on the ablation efficiency and the thermal effects caused by the heat transfer through enamel and dentin to the pulp during cavity preparations. Hibst and Keller[19] tested the ablation of some restorative filling materials, including composite resin, and a greater thermal side-effect on adjacent substances was suggested compared to enamel and dentin. However, the literature contains little on real effects of laser on the pulp when used for the removal of composite resin restorations.

Considering the increasing use of esthetic restorative materials and the improvement of the techniques for their removal, the aim of this study was to evaluate the ability of the Er:YAG laser to remove composite resin restorations, assessing the time required for this removal and analyzing the temperature alteration caused by the laser.

MATERIALS AND METHODS

Twenty freshly extracted bovine incisors were selected for this study. The teeth were thoroughly cleaned with a hand scaler and rubber cup/pumice paste, and were stored in distilled water at 4°C until use.

The teeth were decoronated at the cementoenamel junction. The crowns were bisected longitudinally with a water-cooled diamond saw in a sectioning machine (Minitom, Struers A/S; Copenhagen, Denmark), dividing the tooth into a labial and a lingual fragment. The lingual fragment was discarded, providing a total of 20 labial specimens (4 x 4 x 2.5 mm). Each labial fragment was fixed in a polytetrafluoroethylene cylinder with its surface parallel to the device and ground wet with #400-grit silicon carbide paper in a polishing machine (Politriz, Struers A/S) until obtaining 0.5-mm-thick enamel on the labial side and 1.5-mm-thick dentin on the inner side.

Class I cavities (2 x 2 x 1 mm) were prepared with a #245 high-speed carbide bur and etched with 35% phosphoric acid gel (3M ESPE; St. Paul, MN, USA) for 15 s, thoroughly rinsed, and excess water was blotted with absorbent paper. Two consecutive layers of a single-bottle adhesive system (Single Bond, 3M ESPE) were applied, gently air thinned for 5 s, and light cured for 20 s using a visible light-curing unit with 480 mW/cm^2 output (XL 3000; 3M ESPE), as measured with a curing radiometer. The cavities were restored with a hybrid light-cured composite resin (Z250; 3M ESPE, shade A4), inserted in two increments, and each polymerized for 20 s (Fig 1). The restored specimens were stored in distilled water at 37°C for 24 h and thereafter the restorations were polished with aluminum oxide-impregnated disks (Super-Snap, Shofu; Tokyo Japan) in a decreasing order of abrasiveness.

The specimens were randomly assigned to 2 groups (n = 10), according to the technique used for composite filling removal. In group I (control), the restorations were removed using a water-cooled #1092 cylindrical diamond bur (KG Sorensen, São Paulo, SP, Brazil) in a high-speed handpiece (Dabi-Atlante S.A., Ribeirão Preto, SP, Brazil). Each bur was discarded after five preparations. In group II, the composite restorations were removed using a Kavo Key II Er:YAG laser device emitting at 2.94 mm wavelength (Kavo Dental; Biberach, Germany), 250 mJ, energy density (fluence) 80 J/cm^2, 6 Hz pulse repetition rate. The laser beam was delivered in noncontact, focused mode, with a fine water mist at 5 ml/min. Laser beam spot size (0.63 mm) was verified through SEM measurement at a 12-mm distance of irradiation, pulse duration was 250 to

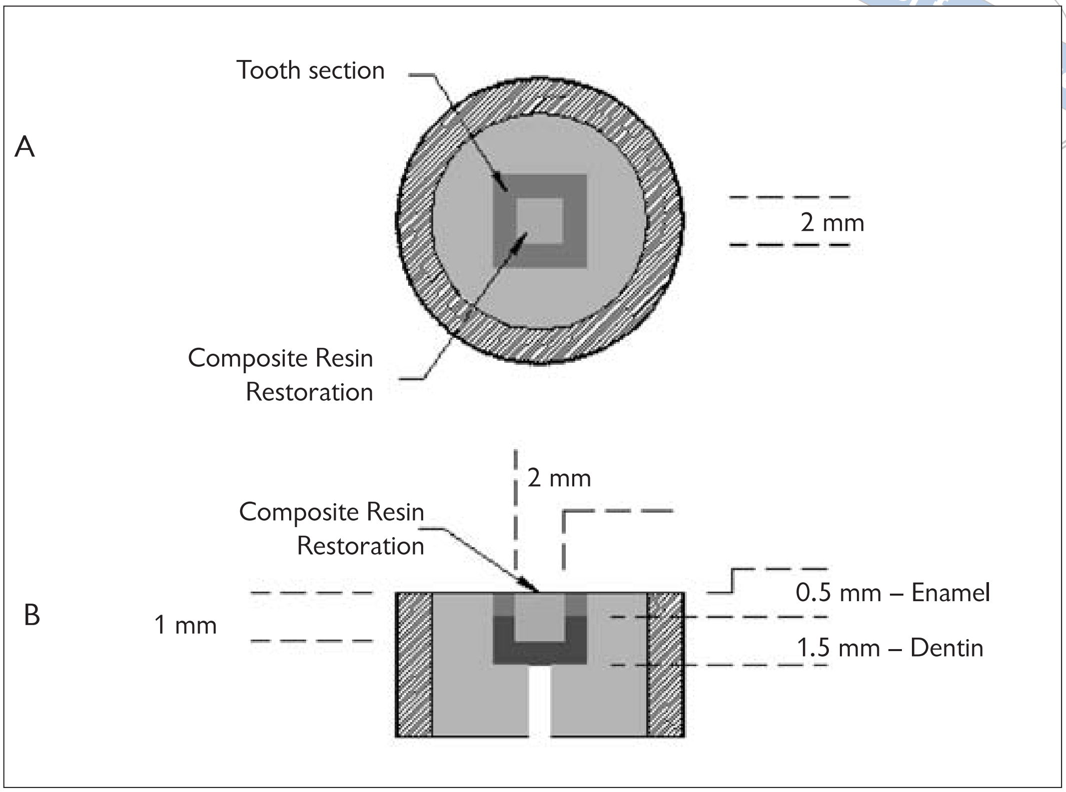

Fig 1 Schematic illustration of specimen A: top view; B: transverse cut.

500 ms, and the 2051 handpiece was used with a removable tip attached to a flexible fiber delivery system. The irradiation distance was standardized by using a custom-made apparatus consisting of two parts: a holder to fix the laser handpiece in such a way that the laser beam was delivered perpendicular to the specimen surface at a constant working distance from the target site, and a semi-adjustable base, on which a plexglass plate with the fragment attached to it was firmly fixed with wax. Two operators operated the apparatus' micrometer screws so that the semi-adjustable base was alternately moved in both right-to-left and forward-to-back directions, thus allowing the laser beam to act on the entire composite restoration. For every specimen, the irradiation distance was checked with a ruler.

The thermocouple was put in contact with the specimen at the dentin wall. The temperature was recorded immediately before and after the removal of the composite restorations (Fig 2). The time (in seconds) required for removing the restorative material in each group was measured with a chronometer.

In both groups, completion of restoration removal was established by visual inspection. The composite resin shade used in the experiment was easily distinguishable from the dental structure. Next, the specimens were cleaved longitudinally in the middle, and the surrounding and deep walls were analyzed with a stereomicroscope under 40X magnification in order to check for the presence of restorative material.

Means of working time and temperature change were calculated for each group and data were analyzed statistically by the non-parametric Mann-Whitney test.

RESULTS

Group I (control), in which restorations were removed with a rotating instrument, showed an average temperature increase of 1.2°C, and group II, in which restorations were removed with laser, the average temperature increase was 4.0°C, statistically significantly different from the control group. The data are summarized in Table 1.

The time spent for the removal of restorations was 25.6 s for those performed with a rotating handpiece, as opposed to 49 s for the removal with laser, which is a statistically significant difference. The time required for restoration removal is summarized in Table 1.

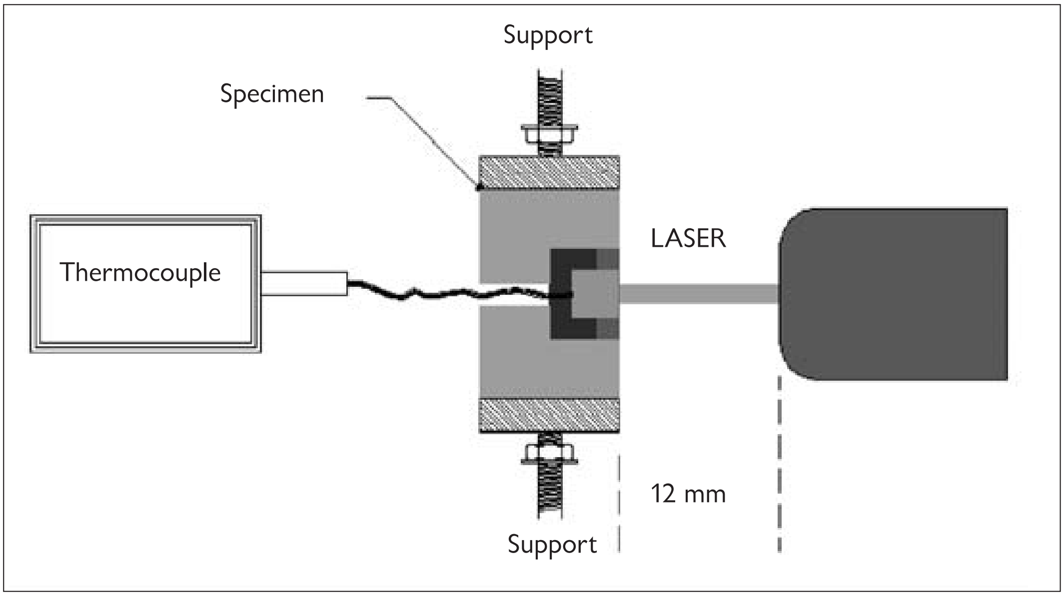

Fig 2 Specimen, support, thermocouple! Schematic illustration of removal of the restoration with laser and temperature measurement.

Table 1 Medians, means, and standard deviations of temperature rise and time required for composite resin removal

	High-speed handpiece		Laser Er:YAG	
	Median	Mean (SD)	Median	Mean (SD)
Temperature (°C)	1.0	1.2 (±1.1)	3.7	4.0 (±1.8)
Time (s)	20.0	25.6 (±10.3)	47.0	49.0 (±4.5)

It was also observed that more specimens in the laser group than in the rotating instrument group presented an incomplete removal of the restoration; in this case, it was noticed that the remainder of the restoration was restricted to a tenuous resin layer in the cavity.

DISCUSSION

Analyzing the time spent for restoration removal, it can be observed that the laser took twice the time of the rotating instrument. It was also observed that the cavities produced by the laser exhibited irregular walls and incomplete removal of restorations. This irregularity also was observed in a study by Dostalová et al,[17] in which the laser ablation presented greater surface irregularity upon caries removal.

The laser promotes a fusion of the composite resin, and during removal, it was observed that the thinner the remainder of restoration, the more difficult it was to visualize the difference between the restorative material and the dentin of the cavity. These factors made it difficult for the operator to assess the result, leading to incomplete removal of the composite resin.

The longer time spent for restoration removal by laser may be caused by the parameters employed, which were chosen to minimize increases of temperature, since there are no established parameters from previous studies for the removal of filling material.

The temperature increase of 4.0°C observed with the laser is consistent with that observed for cavity preparation in enamel and dentin.[10,18] However, some authors reported smaller temperature increases in dental hard tissues when compared with composite ablation.[20] In spite of the greater temperature increase than that found for the removal with the rotating instrument (1.2°C), the temperature increase caused by laser probably did not cause any damage to the pulp, according to a study[21] which demonstrated that pulp damage could be caused by temperature increases higher than 5.6°C and total pulp necrosis with a 16°C increase. Other research[20] has shown that temperature increase is also related to the employed energy as well as to the required ablation rate. Thus, other parameters should be tested.

Although it has been demonstrated that the laser presented results lower than the rotating handpiece, clinical studies show that approximately 70% of the patients do not feel any vibration during the laser microexplosions and 100% of the patients feel no pain or discomfort, thus indicating that this is a safe method for the pulp.[17] Besides, due to its ability to ablate dental tissues, the Er:YAG laser has been pointed out as an excellent technology for operative dentistry, being the most promising alternative to rotating instruments. Nevertheless, further studies are still required before it becomes a routine method in the dental practice.

CONCLUSION

With advances in dentistry and dental care, a decrease in the incidence of primary carious lesions has been observed. However, many existing restorations are clinically unsatisfactory. Therefore, many clinicians lose a great part of their time and get a substantial part of their incomes replacing restorations. Thus, this study is relevant for dental research due to the great demand for the substitution of restorations and the good cost:benefit ratio of laser equipment.

Based on the above results, it may be concluded that with the parameters used, the Er:YAG laser is safe for the removal of composite resin restorations, despite the fact that it required a longer time for the procedure and presented some difficulty for the total removal of restorative material.

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