Original Article

Comparison of Temperature rise during cavity preparation with high and low torque hand pieces and Er:YAG laser

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Abstract:
Aim: To compare intra-pulpal temperature increases produced by a high-speed high-torque (speed-increasing) handpiece, a high-speed low-torque handpiece (air-turbine) and an Er:YAG (Erbium: Yttrium-Aluminum-Garnet) laser.
Materials and methods Ninety freshly extracted premolars were reduced to a dentine thickness of 2.0 mm. Class V preparations were prepared to a depth of 1.5 mm, measured with a caliper or by a mark on the burs. A thermocouple was placed inside the pulp chamber to determine temperature increases (°C). Analysis was performed on the following groups (n = 30) treated with: G1, low-torque handpiece; G2, high-torque handpiece; and G3, Er:YAG laser (2.94 μm at 250 mJ/4 Hz), all with water cooling. The temperature increases were recorded with a computer linked to the thermocouples.
Results: There were significant statistical differences among the groups ($p = 0.086$). All the groups tested did not have a change of temperature that exceeds the threshold of 5.5°C.
Conclusion Temperature response to the low and high torque hand pieces seemed to be similar, however the Er:YAG laser generated a lower temperature rise.
Key words: Er:YAG laser, intrapulpal temperature, torque hand pieces

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Introduction

Removal of dental caries provide an adequate shape to receive the restorative material prior to the application of dental materials on dental structures. The tooth preparation can be done with a conventional (high-speed low-torque air turbine) or modified (high-speed high- torque) hand piece. The use of lasers in dentistry is an alternative method that is gaining importance, as the laser can provide more comfort to the patient by reducing pain, noise and need for an anaesthetic.[1] Dentine is a structure full of tubules. Conduction of thermal stimuli is greater at deep dentine as

less dentine is observed between the tubules, while the tubules present a greater diameter. The movement of dentinal fluid and the hydraulic ability to generate pressures on the pulpal tissue occurs through the dentine tubules.[2] The hydraulic pressure decreases with increasing distance from the pulp and dentine thickness.[3,4] Temperature increase is able to promote alterations in pulpal tissue. The main cause of post-operative inflammation or necrosis of the pulp is probably due to the injury of dentine, a tissue in direct functional and physiological connection with the pulp.[5,6] High-speed hand pieces are perhaps the most important equipment in a dental office.[7] Differences in cutting mechanisms were seen between hand pieces with high and low torque, especially when the loads and cutting rates were increased.[8] The high-speed hand pieces generated an increase in pulpal temperature and pressure that decreased with an increase in the thickness of the remaining dentine.[9] Because the wavelength of the Er:YAG (Erbium:Yttrium-Aluminum-Garnet) laser can absolve water and hydroxyapatite, it can be indicated for the removal of caries and cavity preparations.[10,11,12]
The treatment with an Er:YAG laser needs to be performed with constant water cooling because macroscopic observations of the dentine irradiated without water cooling showed dark lesions, suggesting carbonisation of the tissue. Under constant water cooling, the high-speed turbine and laser instrument generate similar heat increases; water cooling is essential to avoid destructive temperature increases. The purpose of this study was to compare the intrapulpal temperature changes when the teeth were treated with high-speed handpieces (low and high torque) and an Er:YAG laser. The null hypotheses of this study are that high torque hand piece causes a rise in the intrapulpal temperature and that the Er:YAG laser induces a smaller intra-pulpal temperature change.[13,14]

Materials and Methods

In this study, 90 freshly erupted maxillary premolars, indicated for orthodontic extraction were used. The specimens were stored in distilled water and frozen at -18ºC until they were used.[15] This study was approved by the Ethical Committee. The roots were sectioned at the third cervical with a carborundum disc and disposed. The coronal pulp was removed with a dentineal curet (Duflex Lucas # 86, SSWhite,) and endodontic H files (H 20, 25, 30, Maillefer), and the pulp chamber was irrigated with distilled water and gently dried with air. The buccal surfaces were ground under water cooling with SiC grit 80 paper, mounted on a trimming machine, to remove the enamel and expose the dentine. During this procedure, a caliper was used to standardise the dentine thickness at 2 mm. Subsequently, the mesial and distal faces of the specimens were reduced in the trimming machine, to allow the fixation of the specimens in a container with water and a thermostat, to maintain the temperature at 36±1^{o}C. All the specimens were also sectioned in the occlusal and cervical face, the size of the specimens were standardised to 10 mm, and half of this distance (5 mm) was demarcated as the preparation area.
The teeth were divided into three groups, with thirty specimens each, for each piece of equipment used to prepare the cavity (Table 1). The cavity preparations of G1 and G2 were made under constant water cooling with spherical diamond burs. A new bur was used for every five teeth preparations to maintain a constant cut and consequently, a constant pressure and heat in the teeth. For each cavity preparation, the diamond spherical bur (with a stop in 1.5 mm) was inserted in the dentine until there was a remaining dentine thickness of 0.5 mm. A low-load preparation technique was used,

with two seconds of cutting alternated with one second of rest and a 50 to 80 g load applied on the turbine.

The load was measured by preparing the teeth on a laboratory scale (AS 5000 Dentsply Delhi) (Figure 1). For G3, the Er:YAG laser Key III (Kavo, Alemanha) was used with a wavelength of 2.94 µm, and special tip for cavity preparation no. 2060, using the ‘no contact’ mode, with constant water cooling. During this procedure, a caliper was used to check the remaining dentine thickness of 0.5 mm. The dentine was protected with Teflon tape used to demarcate the area to be irradiated with the laser. Recording of temperature changes all specimens had a thermal-conductive paste inserted into the pulp chamber to facilitate the heat conduction from the chamber walls to the thermocouple. The active apex of T thermocouple (copper (+) x constantan (-)) was inserted in a way so that was in direct contact with the internal buccal dentine wall, next to the place where the tooth was prepared. The pulp chamber was filled out and the apical portion of the tooth was sealed with an adhesive mass (Multi-Tak/Pritt) to firmly hold the thermocouple in the correct position. The thermocouple was positioned at a height of 5 mm, corresponding to the standardised measure presented previously. The temperature rises were recorded with a data collector (ADS 2000 IP-Lynx, Tec. Delhi) linked to a personal computer. The initial and peak temperatures were recorded during the cavity preparations. Data were organized and analyzed using the one-way analysis of variance (ANOVA) and Tukey statistical test.

Results

The pulpal temperature changes during tooth preparation in deep cavities (0.5 mm remaining dentine thickness) are presented in Table 2. With the information presented in Table 2. It is observed that the values do not present the same distribution around the mean. The standard deviation of hand pieces (low and high torque) present correspondent values, Table 2 Temperature increases (ºC) for test groups 3 more than two times that of the Er:YAG laser standard deviation. When comparing the central, mean and median tendencies of the data using the parametric statistical test, Analysis of Variance (ANOVA), Table , and non-parametric Kruskal-Wallis test (kw = 7.05; df = 2; p-value = 0.012 <0.05), it is observed that the groups are significantly different. While comparing the mean values (Tukey’s test) and median values (Dun’s test), it is possible to verify that the low torque hand piece is different from the Er:YAG laser, while the high torque hand piece presents an intermediary behaviour between the values of the low torque handpiece and Er:YAG laser.

Table 1: List of Equipments used

Group	Equipment
G1	Air turbine low torque
G2	Air turbine high torque
G3	Er:YAG Laser

Table 2: Temperature (^{o}C) increases for Test groups

	High Speed Low Torque	High Speed High Torque	Er:YAG Laser
Mean	1.56	1.29	0.69

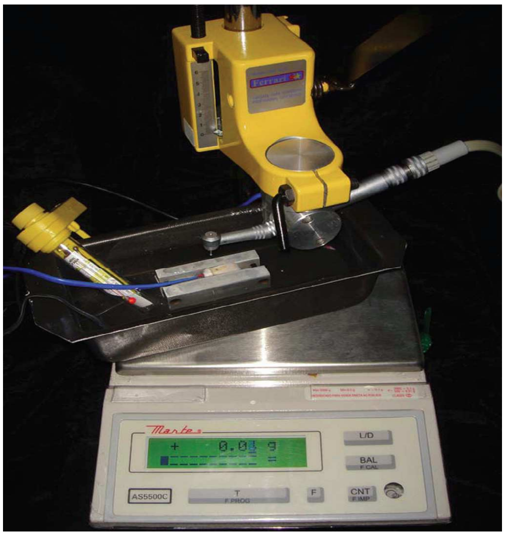

Figure 1: Tooth in position on the Laboratory Scale before starting cavity of preparation.

Discussion

Several methods can be used to remove carious tissue and prepare the dental cavity. The purpose of this study was to compare the pulpal heat generated when teeth were prepared with an Er: YAG laser and a diamond bur on either a high-speed low-torque (air-turbine) or a high-speed high-torque (speed-increasing) hand piece.

In this study, cavity preparations were made on all specimens to a dentine thickness of 0.5 mm, as it has been shown that, at this distance from the pulp, the injuries on dentine have a high effect on the pulpal tissue.[3,4] The temperature variation using these hand pieces was analysed to correlate the influence of this temperature alteration on the dental pulp. Srimaneepong et al. (2002),[9] evaluated the temperature changes after the application of a Nd:YAG laser and a high-speed diamond bur with a remaining dentine thickness of 2.1, 1.5, 1.0 and 0.5 mm. The results demonstrated that 0.5 mm dentine thickness had the highest increase of pressure and temperature in the pulp chamber. For all of the studied groups in the current study, constant water cooling was used, because in agreement with Attrill et al[16] the absence of water cooling can promote great increases in temperature. While analysing the behaviour of low and high torque hand pieces, Watson et al. (2000)[8] verified that there was no evidence of increased tooth cracking or heating with these hand pieces, indicating no deleterious effects on the tooth. The results obtained in the current study allowed us to verify that using low and high torque hand pieces did not present significant statistical differences. The Er:YAG was also used in this study to prepare the cavity on deep dentine, because, according to Hibst and Keller (1989),[17,18] the Er:YAG laser offered high ablation efficiency and low thermal side effects. Some Er:YAG laser beams could penetrate to deeper areas than the ablated area and damage the nerve fibres and terminals, which might be a mechanism of pain reduction in cavity ablation with the Er:YAG laser.[1]

Keller et al. verified a mean temperature rise of 1.68ºC in the pulpal chamber using CO_2 and morphologically unaltered dentine surfaces, demonstrating the safe and tissue preserving character of the laser.[19] But Malmstrom et al. (2001) using pulsed CO_2 laser light for soft tissue surgery found detrimental changes to oral hard tissue and to the pulp. The pulp chamber temperature rise ranged from 0.5 to 19°C degrees depend-ing on the distance of pulp chamber, also SEM revealed crystal fusion in both enamel and dentine tissue.[20,21] Effects pulp tissue and pulpal blood flow were current study are in agreement with the of distance from the pulp and thickness on the observed by Watanabe et al[22] and Friedman et al[23] Srimaneepong et al[9] verified that, during the use of a Nd:YAG laser, there was an increase in pulpal temperature and pressure as the power (and corresponding energy density) of laser irradiation increased and the remaining dentine thickness decreased.

The 3W laser (energy density 467J cm-2) created the highest mean increase of pulpal temperature (1.31^{o}C) and pressure (1.75 kPa), while the 1W laser (energy density 156J cm-2) promoted 0.34^{o}C and 0.53 kPa mean increase of temperature and pressure, respectively.
In the current study, the irradiation of the Er:YAG laser at energy density of 80.19J/ cm2 created a mean increase in temperature of 0.69^{o}C. The reduced increase of temperature is in agreement with the findings of Keller & Hibst[10] who verified that the majority of the incident energy is consumed in the ablative process and only a small fraction of the energy results in heating the remaining tissue, causing no damage. The reduction of temperature change is also obtained from the use of constant water cooling, in accordance with Attrill et al. (2004),[16] who observed that the application of an Er:YAG laser without water cooling would exceed the temperature increase threshold of 5.6ºC. Class I and class V cavity preparations with Er:YAG laser in enamel, cementum and carious tissue was carried out by Oelgiesser et al.[18] at different irradiation energies (600-1000 mJ) and pulse frequencies (7-12 PPS), with an air-water spray as a cooling system. The authors stated that the elevation measured in the pulp chamber during lasing with various energies and pulse rates was low and did not exceed the critical value of 5.5ºC.[5]

Conclusion

Within the limits of this study, the null hypothesis that there would be a difference between the rise of intrapulpal temperature when cutting with high and low torque hand pieces was rejected, as these groups did not present statistical differences. However, the null hypothesis that the Er:YAG laser would induce a smaller intra-pulpal temperature change was accepted, as this laser promoted a smaller increase in intrapulpal temperature in comparison to the hand pieces. All of the equipment used during cavity preparation, under water cooling, did not exceed the critical temperature of 5.5^{o}C.

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