Possible Applications of an Er:YAG Laser Combined with a Laser Application for Wide Area (LAWA) System: An In Vitro Pulpal Temperature Study

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INTRODUCTION

Heat is generated during laser applications, which, if not controlled, can cause hard tissue destruction and pulpal necrosis. Previous studies have shown that both high-speed handpieces and an Er:YAG laser both used on dental hard tissue cause pulp temperature increases of various degrees.¹² A study by Zach and Cohen¹ using Macaca rhesus monkeys demonstrated that a pulp temperature rise of 5.6°C can cause pulpal necrosis. (Editor’s note: The Zach and Cohen study’s data expressed the temperature rise as 10°F.)

The authors have tested an add-on accessory, patented by one of them, which is a scanner system that allows an existing dental laser beam to interact with a larger target area, and termed the system Laser Application for Wide Area (LAWA). Representational different beam shapes produced are shown in Figure 1. The LAWA handpiece enables surface scanning during laser application that is designed to prevent the possibility of repetitive interactions at the exact same tissue point, thus helping to prevent a local temperature increase at that point.

OBJECTIVE

This study was conducted to compare in vitro pulp chamber temperature changes induced by an Er:YAG laser and an Er:YAG laser with LAWA system using the same laser parameters.

MATERIALS AND METHODS

Specimen preparation

Twenty intact and noncarious human maxillary first premolars extracted for orthodontic reasons were collected. The teeth were cleaned of any residual tissue tags, pumiced and washed under running tap water, and stored in a solution of 0.1% thymol until use. The roots of the teeth were mounted in individual self-curing resin blocks (Meliodent, Bayer Dental, Newbury, UK) with the long axis oriented perpendicular to the surface of the resin block to 1 mm below the cemento enamel junction.

To facilitate the positioning of the thermocouples into the pulp chamber, standardized tunnel-shaped preparations (diameter = 2 mm) involving the pulp chamber were made on the mesial surfaces of the teeth with a round diamond bur (lot 0092667, Diatech, Coltène/Whaledent AG, Altstätten, Switzerland) under copious water. The thickness of the distal approximal wall was measured with a decimal caliper (A. Schweickhardt GmbH & Co. KG, Tuttingen, Germany) and prepared to allow a standard 2 mm of enamel/dentin thickness on their sound distal surfaces. Those teeth that had greater enamel/dentin thickness were reduced with a parallel diamond bur under water spray.

Laser application and temperature change measurements

The specimens were randomly assigned to Er:YAG laser and Er:YAG+LAWA system groups (n = 10/group). The probe of a thermocouple was placed inside the pulp chamber through the tunnel up to the mesial/distal pulpal wall of the pulp chamber. The pulp chamber was filled with warm 10% gelatin solution.

Figure 1: The laser beam can be shaped into the desired form with the LAWA system by using a vertically and horizontally moving mirror system placed inside the handpiece. The red aiming beam depicts the exact shape of the invisible Er:YAG radiant energy. a: vertical-short line; b: vertical-long line; c: horizontal line; d: rectangle; e: square.
and allowed to solidify. The gelatin solution filled the pulpal chambers, eliminating the dead space and holding the thermocouple in place within the pulp chamber. Both groups used an Er:YAG laser (Fidelis II, Fotona d.d., Ljubljana, Slovenia, EU) emitting pulsed infrared radiation at a wavelength of 2.94 micrometers at 300mJ (10 pulses/sec, 300-msec pulse duration) from a quartz noncontact tip with a diameter of 900 µm. An external water-cooling system sprayed 10 ml of water per minute. For the first group, the beam was aligned perpendicular to the specimens at distance of 1 mm and moved in a sweeping fashion, screening the test surface with a uniform motion to form a rectangle of 1 mm x 2 mm by hand over an average period of 155 seconds exposure period over the entire area. For the second group, the same laser and water spray parameters were used with the addition of the LAWA device, which provided a 1200-Hz horizontal, 50-Hz vertical scan rate and formed a rectangle of 1 mm x 2 mm. The handpiece was held still during application.

The temperature increases were recorded with a thermocouple (HH501DK, Omega Engineering, Inc., Stamford, Conn., USA) which was linked to a notebook computer (Toshiba, Satellite A105-S4004, Tokyo, Japan) with specific software (IR-Graph v. 1.02, Raytek Corporation, Santa Cruz, Calif., USA) that recorded the readings that were made every 0.125 seconds. The laser was applied until the thermocouple indicated a sudden temperature increase in the pulp chamber. The temperature variation was determined as the increase from baseline temperature to the highest temperature recorded after the initial tooth preparation. Data were collected for a 20-second stable baseline period prior to testing and for a period of up to 360 seconds after the preparation had been completed to ensure that the temperatures returned to the baseline levels.

Statistical Analysis
Statistical analysis was performed using software (SAS© System for Windows®, release 8.02/2001, SAS Institute Inc., Cary, N.C., USA). The results obtained from the mean temperature changes of each group were statistically analyzed (Kruskal Wallis and Mann-Whitney U) to determine the significant differences between the mean preparation durations. The level of significance was chosen as 0.05.

RESULTS
Significant differences between the two test groups ($P < 0.05$) were observed. The mean temperature rise values (mean temperature ± SD) of Er:YAG group ($4.47 ± 0.51° C$) was significantly higher than the Er:YAG+LAWA group ($2.43 ± 0.53° C$) ($P < 0.05$). This is depicted in Figure 2.

CONCLUSIONS
In vitro pulp chamber temperature increases with Er:YAG laser with and without the LAWA system under water cooling were below those deemed to be harmful for the pulp. The use of the LAWA system appears to prevent the local temperature increases that might result from the multiple interactions at the same point on the target tissue.

AUTHOR BIOGRAPHIES
Dr. Bülent Gökçe graduated in 1998 and practices in the Ege University School of Dentistry Department of Prosthodontics. He received his PhD in 2004 and Associate Professorship in 2010. He is a national and international speaker and has authored and co-authored several articles. Dr. Gökçe may be contacted by e-mail at bulentgokce@yahoo.com.

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Figure 2: Intrapulpal temperature rises occurring following Er:YAG laser and Er:YAG+LAWA irradiation by time.
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Disclosures: Drs. Gökçe and Özpinar have no commercial or financial interest relative to this manuscript. Dr. Litvak is a distributor of Fotona medical lasers in Israel, Kazakhstan, Kyrgyzstan, and Azerbaijan. He is also a patent owner of LAWA.

REFERENCES