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Clinical Research

The Local Anaesthetic Effect of a Dental Laser Prior to Cavity Preparation: A Pilot Volunteer Study

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Clinical Relevance

Laser preconditioning has no role in producing alterations in pulpal response.

SUMMARY

Objectives: It has been suggested that laser preconditioning can produce dental anaesthesia. This study aimed to assess the response of the dental pulp to laser preconditioning.

Methods: The effects of laser preconditioning, sham laser (negative control), and composite curing light (positive control) on the response of the dental pulp to electric pulp testing was investigated in this double-blind crossover trial with six volunteers. The Er,Cr:YSGG laser or curing light was shone on a premolar tooth in a sweeping motion for 30 seconds (in the sham treatment, the laser was not activated) in blindfolded volunteers subjected to a consistent aural stimulus. Treatment method at each visit was randomized and performed by a researcher not involved in pulp testing. Teeth were pulp tested twice initially by another member of the research team to get baseline readings, immediately following the treatment, and thereafter every two minutes for 10 minutes. Results were analyzed using analysis of variance and an independent-sample *t*-test.

Results: There were no significant differences in pulpal response between treatments ($p>0.05$).

Conclusion: Laser preconditioning did not affect pulpal response as measured by an electronic pulp tester. Laser preconditioning did not result in any pain or noticeable symptoms for both teeth and soft tissues.

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INTRODUCTION

Although there is some evidence to show that laser tooth preparations can be achieved without local anaesthesia,[1,2] there are still no scientific data to support laser preconditioning as effective or neces-

sary. It has been suggested that shining the Waterlase (Biolase Europe GmbH, Paintweg, Germany) when it is set at its minimum output on the tooth surface induces local anaesthesia.[3] Most of the studies conducted on the clinical application of this laser system as a replacement for the conventional dental drill have been sponsored by the laser's manufacturer or have design weaknesses.[3] To ensure that preconditioning causes no surface enamel damage or an unacceptable rise in the pulp's temperature, we have carried out pilot laboratory tests on extracted teeth.[4] No physical damage was visible on the tooth when the laser was used. This was assessed using both visual assessment and electron microscopy. In addition, measurements recorded in the pulp chambers of extracted teeth showed less temperature rise than that induced by a composite curing light.[5] Such lights are used routinely in restoring teeth with resin composite; the additional temperature rise due to polymerization will be much higher than the light used by itself.[6]

In addition to allowing pain-free cavity preparation, any local anaesthetic effect produced by laser preconditioning could be useful in diagnosis, as it might produce single-tooth anaesthesia, a feature not usually afforded by conventional dental local anaesthetic techniques. Therefore, any potential local anaesthetic effect is worth investigating.

The primary aim of this volunteer study was to assess the response of the dental pulp to preoperative conditioning with the laser set at its minimum power setting (0.25 W). A secondary aim was to determine if this preoperative conditioning produced any unwanted effects. The null hypothesis was that pretreatment with a laser did not differ from pretreatment with a curing light or placebo in the changes in pulpal response to electronic stimulation.

SUBJECTS AND METHODS

Study Design

This study was a crossover trial with six healthy adult volunteers. Each subject received a different treatment at each of three visits. Neither the volunteer nor the researcher measuring the response of the tooth knew which treatment had been given at any particular visit. An unrestored vital first or second premolar tooth (upper or lower) was used as the test tooth, and a similar tooth on the other side of the jaw was used as a control to assess the functioning of the electronic pulp tester. Test and control teeth were randomly allocated. The primary outcome measure was the pulpal response, which was assessed using the electronic pulp tester (EPT). The secondary measure was the subjective assessment of sensation encountered during and after laser or control preconditioning. All active and control pretreatments were applied by the same clinician, and the pulpal responses were recorded by another researcher who was blind to the pretreatment used. Each subject required three visits at least one week apart, with the treatment method at each visit (whether a test or control treatment) selected at random. All subjects had received each treatment at the end of the trial.

Regulatory Approval

Regulatory approval was obtained from the following authorities: a medical research ethics committee (Newcastle & North Tyneside Local Research Ethics Committee 1) and Trust (Research & Development).

Volunteer Selection

Volunteers were selected from the staff/student population of the Newcastle Dental Hospital and Newcastle University. Six subjects were required to have unrestored vital first or second premolar teeth in one quadrant of the jaw (upper or lower) and a similar tooth on the other side of the jaw that was used as a control. EPT tests were performed to assess the response of the pulps of the test and control teeth.

Operators

There were two operators. The chief researcher performed all pretreatment procedures, and the second operator carried out the pulp tester measurements.

Test Method

A Millennium Er,Cr:YSGG laser system (Biolase Europe GmbH, Paintweg, Germany) was used for the active treatment. The laser light was shone on the buccal and the lingual surfaces of the test teeth in a sweeping motion for 30 seconds at 4-mm distance. A mechanical spacer was used to maintain a constant distance from the tooth surface and the laser tip (Figure 1). The laser system was used at the minimum power setting (0.25 W) without cooling. Exposure times were measured using a stopwatch.

Control Methods

A calibrated quartz composite curing light QHL 75 (Dentsply Caulk, Milford, DE, USA), emitting a

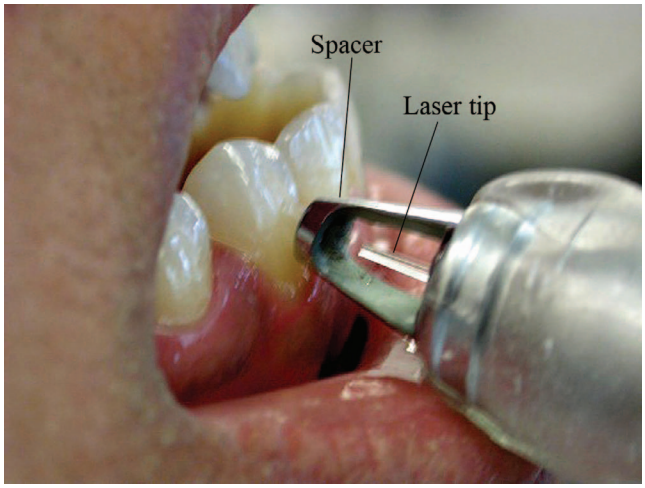

Figure 1. *Mechanical spacer applied to the tooth surface.*

power output of 1500 mW/cm^2, was used for the positive control test. The curing light was calibrated (Coltolux Light Meter, Coltene/Whaledent, Sussex, UK) before and after each set of experiments. The curing light was used on the buccal and the lingual surfaces of the target tooth for 30 seconds in a sweeping motion and at 0-mm distance. The negative control was a sham laser hand piece (ie, not switched on). During exposure to both types of control, the laser device was still switched on to produce the characteristic laser "popping sound" without being actively used. A second curing light machine (not actively used) was also switched on during all tests so that a mixture of sounds was audible. The subjects were blindfolded during treatment. The calibrations of the curing light were checked at the beginning and end of the experiment and were found to be constant.

Pulpal Response Assessment

The standard outcome measure used to determine the presence of anaesthesia in local anaesthetic trials is response to electronic stimulation.[7] An Analytical Pulp Tester (Vitality scanner, Kerr, Analytical Endodontics, Redmond, WA, USA) was used by a researcher who was blind to the selected treatment (test or control). Tooth surfaces were carefully isolated and dried with cotton wool. The pulp tester tip was covered with a conducting medium (Prophylaxis paste, Kemdent, Swindon, UK) and then applied on the mid-surface of the occlusal one-third of the buccal surface of the tooth.[8] To complete the circuit, the volunteer was instructed to hold the handle of the pulp tester device and to raise his or her hand at the occurrence of any sensation. Numeric values corresponding to the intensity of stimulation were displayed on the device and recorded. The maximum output of the device corresponded to a reading of 80. No response to this maximum reading is considered successful anaesthesia. The batteries of the device were replaced by a new set on a weekly basis. Both teeth (test and control) were pulp tested twice initially to get the baseline readings. Single readings were then taken immediately following the treatment and then every two minutes for 10 minutes. The test tooth was pulp tested first during each testing cycle.

Screening for Symptoms

Volunteers were given a questionnaire to record how the tooth and surrounding tissues felt during each preconditioning treatment. The discomfort level was recorded on a 100-mm visual analogue scale (VAS) with the anchors being "no pain" and "unbearable pain." Volunteers were asked to place a vertical mark on the scale where it best described his or her pain level.

Statistical Analysis

The pulp tester readings of the test and the control treatments were subjected to analysis of variance (ANOVA) and post hoc Tukey multiple comparison test to compare the results at each two-minute interval from baseline to 10 minutes, a Student independent-sample t-test was used to compare the baseline EPT readings of individual pairs of teeth (test and control). VAS results were measured in millimeters and presented as whole numbers. The software SPSS 15.0 (SPSS Inc, Chicago, IL, USA) was used. The level of significance was set at $p<0.05$.

RESULTS

The six volunteers (two males and four females) had a mean age of 33 (range 27–41). Although there were minor variations in baseline readings between individual pairs of teeth (test and control) there were no significant differences as a group ($t=0.8$, $p=0.425$). The mean and standard deviation of the pulpal response assessment over time are shown in (Table 1). There were no significant differences in the changes in pulpal response between treatments at any time (ANOVA, $p>0.05$). Laser preconditioning did not achieve anaesthesia in any of the volunteers as measured by no response to an EPT reading of 80. All teeth responded to the pulp tester at every reading. None of the subjects experienced any pain greater than zero as measured by VAS at any time during the trial either for teeth or for soft

Table 1: *Means ± Standard Deviation of EPT Pulpal Response Measurements Over Time*

Time (Minutes)	Laser (n=6)	Sham Laser (n=6)	Curing Light (n=6)
Baseline	37 ± 10	37 ± 8	34 ± 5
0	39 ± 14	39 ± 7	38 ± 7
2	42 ± 11	39 ± 7	37 ± 5
4	40 ± 11	38 ± 6	41 ± 7
6	38 ± 9	38 ± 6	40 ± 8
8	40 ± 8	39 ± 6	40 ± 7
10	38 ± 10	39 ± 5	38 ± 7

tissues. No symptoms were noted related to the procedure except for one volunteer who reported the noise and the smell as the only causes of discomfort.

DISCUSSION

The literature on the local anaesthetic effect of dental lasers is sparse. It has been reported that cavity preparation using lasers can be achieved without local anaesthesia.[1,2] However, it is not clear whether laser preconditioning is necessary or effective as a local anaesthetic method. This study was aimed to assess the response of the dental pulp to preoperative conditioning with the laser when set at its minimum power setting. It has been shown that pulpal anaesthesia is considered achieved if the maximum reading of 80 on the pulp tester does not generate discomfort.[9-11] The data obtained from the current study would suggest that laser preconditioning did not achieve a local anaesthetic effect, as all volunteers reported a response to an electronic pulp stimulus at an average reading of 38.7 immediately following laser preconditioning. Indeed, the responses of the dental pulp following laser and both control treatments were similar (Table 1). The electronic pulp tester is technique sensitive and has a number of limitations and requirements. All EPT measurements undertaken in this study were performed by the same operator to ensure that the application method involving isolation technique and application site was consistent. Since the different conducting media influence the responses gained from electronic pulp testing,[12] the same conducting medium was used throughout the trial to ensure that a maximum steady current passed from electrode to tooth.

The number of volunteers was small in this study. There is a lack of relevant data in the literature on which to base a power calculation to inform a sample size. Even with small numbers, it is clear that preconditioning does not influence the outcome of electronic pulp testing. Nevertheless, while preconditioning did not affect the response to electronic pulp testing, we cannot be sure that it has no effect on reducing discomfort during cavity preparation.

Matsuda and others[13] reported that several types of laser (Ar^+ Nd:YAG and He-Ne) have the potential to block nerve conduction, likely through sodium and potassium channels "by means of heat or photochemical effects." Such reductions appear to be power, wavelength, and time dependent. Furthermore, low-intensity lasers[14] and high-intensity lasers[15] have been used for the treatment of dentin hypersensitivity, but the exact mechanism by which lasers might affect pulp is still not known, and the safety of the procedure is still being investigated. Although there was no effect in the present study on electronic pulp test response, the possibility remains that continued laser irradiation, particularly at higher power, may have a local anaesthetic effect during cavity preparation. In order to determine if laser preconditioning produces any local anaesthetic effect, a further clinical trial with an active intervention is needed. A number of factors that may influence pulp sensitivity have been identified, such as the clinician's approach to the patient[16] and hypertension.[17] In the current study, we were careful to adopt a calming approach to the patients, and no patients diagnosed with hypertension were included in the study.

The VAS, which is widely used in pain studies,[18] was chosen to assess pain intensity and to allow parametric analysis of the data. All the volunteers recorded no discomfort during and at the end of all three visits. One subject reported the noise and the smell from the electric motors of the curing light and the laser units as being unpleasant.

CONCLUSIONS

- Laser preconditioning of teeth prior to cavity preparation did not provide a local anaesthetic effect in adults as measured with an electronic pulp tester. There were no significant differences

in pulpal response following laser irradiation compared to control treatments.
- Preconditioning did not result in any pain or noticeable symptoms at any time in the trial for both teeth and soft tissues regardless of the type of pretreatment as assessed by subjective measures, except for one subject who reported the noise and the smell as unpleasant.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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