Thermal effects of the Er:YAG laser on a simulated dental pulp: a quantitative evaluation of the effects of a water spray

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Abstract

Objectives. To quantify the temperature increments in a simulated dental pulp following irradiation with an Er:YAG laser, and to compare those increments when the laser is applied with and without water spray.

Methods. Two cavities were prepared on either the buccal or lingual aspect of sound extracted teeth using the laser. One cavity was prepared with water spray, the other without and the order of preparation randomised. Identical preparation parameters were used for both cavities. Temperature increments were measured in the pulp chamber using a calibrated thermocouple and a novel pulp simulant.

Results. Maximum increments were 4.0 °C (water) and 24.7 °C (no water). Water was shown to be highly significant in reducing the overall temperature increments in all cases (\(p<0.001\); paired \(t\)-test). None of the samples prepared up to a maximum of 135 J cumulative energy prepared with water spray exceeded that threshold at which pulpal damage can be considered to occur. Only 25% of those prepared without water spray remained below this threshold.

Discussion. Extrapolation of the figures suggests probably tolerable limits of continuous laser irradiation with water in excess to 160 J. With the incorporation of small breaks in the continuity of laser irradiation that occur in the in vivo situation, the cumulative energy dose tolerated by the pulp should far exceed these figures.

Conclusions. The Er:YAG laser must be used in conjunction with water during cavity preparation. As such it should be considered as an effective tool for clinical use based on predicted pulpal responses to thermal stimuli.
Output energy changes of quartz contact probe for Er:YAG laser with tooth ablation.

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The purpose of this study was to examine the output energy changes of the contact probe for Er:YAG laser with tooth ablation and evaluate the effect of contact surface polishing on output energy. The Er:YAG laser was irradiated to enamel of extracted human incisors for 100 min (5 min x 20 times). The output energy of contact probes was measured every 5 min (n = 3). After 100 min, the contact surfaces were polished using silicon carbide paper up to #1500, and the output energy of the probe was measured. The contact surfaces of the probes were observed and analyzed using an EPMA. After 100 min, the output energy showed 49.4% of the energy of an unused probe. After the contact surfaces were polished to #1500, the output energy returned to 96.4% of baseline. It is suggested that the output energy of the contact probe decreased with tooth ablation, and polishing of the contact surface was effective to regain the energy.

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Pulpal temperature increases with Er:YAG laser and high-speed handpieces.

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STATEMENT OF PROBLEM: During tooth preparation, both high-speed handpieces and lasers generate heat, which, if not controlled, can cause pulpal necrosis. PURPOSE: The aim of this study was to compare temperature increases produced by a high-speed dental handpiece with those produced by a relatively new instrument, the Er:YAG (erbium: yttrium-aluminum-garnet) laser. MATERIALS AND METHODS: Thirty bovine mandibular incisors were reduced to an enamel/dentin thickness of 2.5 mm. Class V preparations were completed to a depth of 2.0 mm, measured with a caliper or by a mark on the burs. A thermocouple was placed inside the pulp chamber to determine temperature increases (degrees C). Analysis was performed on the following groups (n=10): Group I, high-speed handpiece without water cooling, Group II, high-speed handpiece with water cooling (30 mL/min), and Group III, the noncontact Er:YAG laser (2.94 microm at 350 mJ/10 Hz) with water cooling (4.5 mL/min). The temperature increases were recorded by a computer linked to the thermocouples. The data were analyzed using the Kruskal-Wallis test. The Dunn multiple comparison test was used as post hoc test (alpha=.05). RESULTS: The average temperature rises were: 11.64 degrees C (+/- 4.35) for Group I, 0.96 degrees C (+/- 0.71) for Group II, and 2.69 degrees C (+/- 1.12) for Group III. There were no statistical differences between Groups II and III; both II and III differed from Group I significantly (P=.000 and P=.002, respectively). CONCLUSION: The preparations made with the high-speed and the laser instrument generated similar heat increases under water cooling. Water cooling was essential to avoid destructive temperature increases when using both the high-speed handpiece and laser.

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Adhesion and growth of cultured human gingival fibroblasts on periodontally involved root surfaces treated by Er:YAG laser.

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BACKGROUND: The application of Er:YAG laser irradiation, approved in 1997 to be used on dental hard tissues, has been investigated for periodontal therapy. The aim of this study was to analyze the biocompatibility of root surfaces treated by Er:YAG laser. METHODS: Adhesion and growth of cultured human gingival fibroblasts on root surfaces treated by either irradiation with Er:YAG laser or curet were compared. Thirty single-rooted teeth extracted because of periodontal disease were used. Calculus deposits on all experimental surfaces were removed, and the teeth were divided into three groups according to the applied treatment: group A, root planing with Gracey curet no. 3/4; group B, two irradiations with laser (60 mJ/pulse, 10 Hz; 10" each with 10-second interval, 3 J/cm2); group C, two irradiations with laser (100 mJ/pulse, 10 Hz; 10" each with 10-second interval, 5 J/cm2). Fragments (5 mm x 6 mm) were obtained from the experimental surfaces. Then, 1 x 10^3 cells were seeded on the top of each fragment. One, 2, and 3 days after seeding the specimens were prepared for scanning electron microscopy analysis, and the cells on the electronmicrographs were counted. The data obtained in triplicate were statistically compared by the Kruskall-Wallis test complemented by the Dunn test (P ≤ 0.05). RESULTS: Human gingival fibroblasts adhered to and grew on all treated surfaces. Group B presented a significantly higher cell count than did the other two groups at days 1 and 2. Three days after seeding the cultured fibroblasts of groups A and B reached total confluence. The cell count of group B was significantly higher than that of group C. CONCLUSION: The surfaces treated with 60 mJ/pulse Er:YAG laser irradiation promoted faster adhesion and growth than surfaces treated with either root planing or 100 mJ/pulse Er:YAG laser irradiation.

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Bond strengths of orthodontic bracket after acid-etched, Er:YAG laser-irradiated and combined treatment on enamel surface.

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Laser ablation has been proposed as an alternative method to acid etching; however, previous studies have obtained contrasting results. The purpose of this study was to compare the bond strengths after acid etching, laser ablation, acid etching followed by laser ablation, and laser ablation followed by acid etching. Forty specimens were randomly assigned to one of the four groups. Two more specimens in each group did not undergo bond test and were prepared for observation with scanning electron microscope (SEM) after the four kinds of surface treatment. After the bond test, all specimens were inspected under the digital stereomicroscope and SEM to record the bond failure mode. Student's t-test results showed that the mean bond strength (13.0 +/- 2.4 N) of the laser group was not significantly different from that of the acid-etched group (11.8 +/- 1.8 N) (P > .05). However, this strength was significantly higher than that of the acid-etched then laser-ablated group (10.4 +/- 1.4 N) or that of the laser-ablated then acid-etched group (9.1 +/- 1.8 N). The failure modes occurred predominantly at the bracket-resin interface. Er:YAG laser ablation consumed less time compared with the acid-etching technique. Therefore, Er:YAG laser ablation can be an alternative tool to conventional acid etching.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

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Influence of an optically thick water layer on the bond-strength of composite resin to dental enamel after IR laser ablation

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Keywords
CO₂ laser • dental enamel • Er:YAG laser • laser ablation • shear-bond strength • water augmentation

Abstract

Background and Objectives
Several studies of hard tissue ablation with Er:YAG lasers have shown that the addition of an optically thick water layer (~1 mm) added to the surface of dental enamel before each incident laser pulse, profoundly influences the rate and efficiency of ablation and the resulting surface morphology. The objective of this study was the determination of laser parameters which result in clinically useful bond strengths without the need for phosphoric acid etching. The hypothesis to be tested was that laser irradiation through a relatively thick layer of water would result in a surface to which composite could be bonded with bond strength similar to surfaces etched with phosphoric acid. This hypothesis is predicated on the assumption that the water prevents the formation of non-apatite calcium phosphate phases on the enamel surface.

Materials and Methods
In this study, a calibrated syringe pump and a motion control system were used to uniformly treat flat enamel surfaces using free-running Er:YAG laser pulses with and without water, and 9.6 μm CO₂ laser pulses on a dry surface for comparison. The rate of water delivery that resulted in the most efficient ablation was determined by profiling the resulting laser incisions using optical coherence tomography. In addition, enamel surfaces of 5 × 5 mm² were uniformly treated and the resulting surface morphology was examined using synchrotron radiation-fourier transform infrared spectroscopy (SR-FTIR), and optical and electron microscopy. The influence of the modified surface morphology on the adhesion of composite resin was investigated.

Results
The shear-bond strength of composite bonded to enamel surfaces irradiated at intensities clinically relevant for caries removal approached values measured for conventional acid etching when the water delivery rate was optimized.

Conclusions
This study demonstrates that composite restorative materials can be directly bonded to laser prepared surfaces without the necessity of further surface preparation and acid etching and that the addition of a thick water layer (~1 mm) prevents the formation of undesirable CaP phases that compromise adhesion to restorative materials. Lasers Surg. Med. 33:264-269, 2003. © 2003 Wiley-Liss, Inc.

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Microtensile bond strengths of an etch&rinse and self-etch adhesive to enamel and dentin as a function of surface treatment.

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In light of the current trend towards "minimal invasive" dentistry, diverse cavity preparation techniques have been introduced as an alternative or addition to common bur instrumentation. This study investigated whether diamond sonoabradion (SonicSys Micro, Kavo), air abrasion (Prep Start, Danville) and Er:YAG laser irradiation (Fidelis) produce surfaces at enamel/dentin that are equally receptive to bonding as traditional mid-grit diamond-bur (Komet) and 600-grit SiC-paper prepared surfaces, of which the latter two served as controls. An etch&rinse adhesive (OptiBond FL, Kerr) applied with and without prior acid-etching and a self-etch adhesive (Clearfil SE, Kuraray) were employed to bond the restorative composite (Z100, 3M ESPE) to the diversely prepared enamel and dentin surfaces. The microtensile bond strength (microTBS) was determined after 24 hours of storage in water at 37 degrees C. The results indicated that the manner of preparation of enamel and dentin prior to bonding procedures significantly influenced the bonding effectiveness of both the etch&rinse and the self-etch adhesive. Using an etch&rinse adhesive, separate acid-etching of air-abraded and Er:YAG-irradiated enamel and dentin surfaces remains mandatory. Bonding to diamond-sonoabraded and air-abraded enamel and dentin was, in general, not different from bonding to conventional diamond-bur prepared surfaces, whereas, bonding to Er:YAG-irradiated enamel and dentin surfaces in general resulted in a significantly lower bonding effectiveness compared to bonding to diamond-bur prepared surfaces.

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Comparative study of microleakage of a pit and fissure sealant placed after preparation by Er:YAG laser in permanent molars.

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PURPOSE: The aim of this study was to assess the microleakage of a pit and fissure sealant on enamel treated with a laser, with and without etching.

METHODS: Sixty non-carious extracted molars were randomly assigned to 2 groups. For both groups, in the mesial halves, the fissures were widened mechanically with a bur and etched for 15 seconds. In group 1, the distal half was prepared with a laser alone; in group 2, a laser was followed by etching. Then the sealant was applied on all teeth. RESULTS: Laser alone showed the highest number of specimens with microleakage (63%) (P < .02) and the highest mean of microleakage (0.76 mm vs 0.12 mm, 0.17 mm, and 0.18 mm; P < .01). CONCLUSIONS: No significant difference was noted between the 2 types of enamel preparation when etching was performed. Laser irradiation did not eliminate the need for etching the enamel surface before applying the sealant.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

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OBJECTIVE: The objective of this study was to evaluate the effect of Er:YAG laser on the formation of CaF(2), after the application of acidulated phosphate fluoride (APF), and its influence on the anti-cariogenic action in human dental enamel. BACKGROUND DATA: Er:YAG laser was designed to promote ablation of the enamel. However, the possibility of using this energy to increase the enamel's resistance to caries has hardly been explored, and neither has its interaction with the use of fluorides. MATERIALS AND METHODS: One hundred and twenty blocks of enamel were allocated to four groups of 30 blocks each: (1) C, control group; (2) Er:YAG, laser; (3) APF; and (4) Er:YAG+APF. Of these, 80 blocks were submitted to pH cycling for 14 days. In the other 40 blocks, fluoride (CaF(2)) was measured before cycling. After pH cycling, surface microhardness (SMH), microhardness in cross-section (converted to mineral contents % vol. min.), and fluoride after cycling (40 blocks) were also determined. RESULTS: SMH decreased in all groups. The control group showed the highest decrease, and Er:YAG+APF showed the lowest decrease (p < 0.05). Groups APF and Er:YAG showed the same results (p > 0.05). Mineral content at depths 10, 20, and 40 microm was lower in the control and Er:YAG groups, and higher in groups APF and Er:YAG+APF. CaF(2) (microgF/cm(2)) deposited before pH cycling was higher in the APF group when compared to the Er:YAG+APF group. Control and Er:YAG groups showed the lowest values (p > 0.05). CONCLUSION: It was concluded that Er:YAG laser influenced the deposition of CaF(2) on the enamel and showed a superficial anti-cariogenic action, but not in depth.

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Assessing microleakage of different class V restorations after Er:YAG laser and bur preparation.

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This study assessed in vitro marginal leakage of class V cavities prepared by turbine and Er:YAG laser and restored with different materials. Sixty cavities with enamel and dentine margins were prepared and assigned to six groups: I, II, III by turbine and IV, V, VI by Er:YAG laser. The following restorative systems were used: groups I and IV: Bond 1 + Alert; II and V: Fuji II LC; III and VI: SBMP + Dispersalloy. After finishing, specimens were thermocycled for 8 h and 45 min (500 cycles), isolated, immersed in a 0.2% Rhodamine B solution, sectioned oro-facially and analysed for leakage. The dye penetration means (%) were: occlusal I: 10.09 (+/- 21.28), II: 3.25 (+/- 10.27), III: 0, IV: 41.77 (+/- 42.48), V: 23.37 (+/- 33.79), VI: 12.66 (+/- 24.06); cervical I: 16.49 (+/- 26.67), II: 4.34 (+/- 13.71), III: 0, IV: 37.71 (+/- 30.47), V: 39.56 (+/- 43.35) and VI: 72.53 (+/- 37.79). The use of Er:YAG laser for cavity preparation yielded higher degree of marginal leakage, as compared with the use of conventional air-turbine. The enamel interface provided better marginal sealing, comparing with dentine/cementum margin. As to the cavity preparation device (i.e. laser or bur), the analysis of the results showed that bonded amalgam and Fuji II LC provided less infiltration, than Alert. On the other hand, for lased cavities, Alert provided the best results, similar to those of Fuji II LC and superior to those reached by bonded amalgam.

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Effects of low power Er:YAG laser on the tooth pulp-evoked jaw-opening reflex.


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BACKGROUND AND OBJECTIVES: Analgesic properties of laser irradiation have been of great interest in the field of dentistry. This study aimed at evaluating the analgesic effects of the Er:YAG laser system in rats during and after laser irradiation. STUDY DESIGN/MATERIALS AND METHODS: A pulsed Er:YAG laser was applied to the oral mucosa of the mandibular incisor at an energy density of approximately 0.1 J/cm²/pulse for 10 minutes at 10 Hz, and the integrated digastric muscle electromyogram in tooth pulp-evoked jaw-opening reflex was used as an index of the nociceptive response. RESULTS: Significant reflex suppression was observed 10 minutes after laser irradiation. The reflex amplitude started to return to its original level about 45 minutes after cessation of laser irradiation. CONCLUSIONS: The Er:YAG laser used at low output levels presented inhibitory effects on the tooth pulp-evoked jaw-opening reflex, suggesting that this laser system may be of use for pain control during various dental treatments. Copyright 2003 Wiley-Liss, Inc.

PMID: 12949946 [PubMed - in process]
Influence of the spatial beam profile on hard tissue ablation. Part I: Multimode emitting Er:YAG lasers.

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Uniform dosimetry is a prerequisite for reproducible laser applications in research and practice. The light-tissue interaction is dependent on the absorbed energy (J) per unit of time (tau) in the case of pulsed lasers, and on the absorbed power (W) per unit of volume (e.g. mm3) in the case of continuous-wave (cw) lasers, and thus directly dependent on the energy distribution within the laser beam. Consequently, precise knowledge of the spatial beam profile, and of the pulse duration and treatment time, is indispensable. The objective of this paper was a theoretical study of the impact of different mode profiles on energy distribution in the beam. Also examined was the question of the influence of changes in the laser parameters on the mode structure. Three erbium:YAG lasers (lambda=2.94 microm) were used for this purpose. The transversal mode structure of the lasers was observed by irradiating thermal paper and verified by means of calculations. The effect induced in the mode profile by changing the pulse energy and pulse repetition rate was investigated. The results of the tests show that changes in the laser parameters result in jumps in the transversal modes and associated energy distributions in the beam. The experiments confirm that simply changing the transversal modes has a substantial effect on the threshold energy required for the ablation of dental enamel (50 mJ with TEM00, 22.6 mJ with TEM31). In practice, inhomogeneity makes it impossible to determine the irradiated area in order to calculate the energy or power density. In addition, the energy distribution in the beam changes as a result of variation of the laser output energy and the pulse repetition rate. Consequently, simply measuring the beam diameter yields a totally incorrect result for the applied flux density when using a beam profile with a relatively high mode.

PMID: 12928822 [PubMed - in process]
In vivo effects of an Er:YAG laser, an ultrasonic system and scaling and root planing on the biocompatibility of periodontally diseased root surfaces in cultures of human PDL fibroblasts.

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BACKGROUND AND OBJECTIVES: The aim of the present study was to investigate the in vivo effects of an Er:YAG laser (ERL), an ultrasonic system and scaling and root planing (SRP) on the biocompatibility of periodontally diseased root surfaces in cultures of human periodontal ligament fibroblasts (PDL).

STUDY DESIGN/MATERIALS AND METHODS: Forty single rooted teeth, considered for extraction due to severe periodontal destruction, have been randomly assigned to the following groups: (1) ERL at 160 mJ/pulse and 10 Hz, or (2) Vector ultrasonic system (VUS), or (3) SRP using hand instruments, or (4) untreated control (C). Immediately after instrumentation, all test and control teeth were extracted and root specimens (4 mm2) were prepared from all mesial and distal surfaces (n=80). Following the prescribed treatments, the root specimens were incubated with human PDL fibroblast cultures. Adherent cells were stained with methylene blue and counted using a reflected light microscope and the cell density per mm2 was calculated. Additionally, the cell morphology was investigated using SEM (n=8 teeth).

RESULTS: Cell counts within each group yielded the following means and standard deviations (cells/mm2): ERL, 111+/−27; VUS, 75+/−25; SRP, 41+/−17; control, 25+/−11. Analysis of variance (ANOVA) revealed significant differences in the number of attached cells between the test and control groups (P<0.001, P<0.001, P<0.01, respectively). ERL and VUS treated specimens showed significantly higher numbers of cells/mm2 than the SRP group (P<0.001, respectively). The difference between the ERL and VUS group was statistically significant (P<0.001).

CONCLUSIONS: The results of the present study indicate that (i) ERL, VUS, and SRP promote the attachment of PDL fibroblasts on previously diseased root surfaces, (ii) periodontally diseased root surfaces inhibit the adherence of PDL fibroblasts, and (iii) the surface structure of ERL and VUS instrumented roots seem to offer better conditions for the adherence of PDL fibroblasts than SRP.

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Ablation of composite resins using Er:YAG laser--comparison with enamel and dentin.

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OBJECTIVES: The purpose of this work is to investigate comparative ablation rate between composite resins and dental hard tissues (enamel and dentin) after Er:YAG laser irradiation to verify possible development of an ultra-conservative dentistry to with minimum effect for the teeth tissue. METHODS: We have used 11 extracted or exfoliated primary anterior and posterior teeth and six extracted permanent molar teeth. Three different types of composite resin were chosen (microfiller, hybrid, and condensable) in terms of chemical and structural composition. Composite tablets and the teeth were irradiated with a Er:YAG laser at different laser beam energy level per pulse (100, 200, 300, and 400 mJ). Diameter and depth of each resulted microcavity were measured and the material removed volumes were calculated. The resulted values were plotted and fitted to allow a comparative observation of the material removed as a function of energy level per pulse. RESULTS: While the idea of ultra-conservative dentistry seems to apply well for enamel of primary and permanent teeth, at the present stage it does not apply well for primary or permanent dentin. For dentin, the composition and content of water makes the Er:YAG laser ablation equal or superior in rate compared with the three used resins. SIGNIFICANCE: This work presents of a comparative study of Er:YAG laser ablation, allowing to analyze the possible selective ablation between composite resin placed and cured and dental hard tissues, with the goal to propose a new clinical technique: differential ablation for composite resin restorations using Er:YAG laser. Copyright 2003 Wiley-Liss, Inc.

PMID: 12913886 [PubMed - indexed for MEDLINE]
Effect of ER:YAG and diode laser irradiation on the root surface: morphological and thermal analysis.

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BACKGROUND: The aim of the present study was to compare the effects of Er:YAG and diode laser treatments of the root surface on intrapulpal temperature after scaling and root planing with hand instruments. METHODS: Fifteen extracted single-rooted teeth were scaled and root planed with hand instruments. The teeth were divided into 3 groups of 5 each and irradiated on their buccal and lingual surfaces: group A: Er:YAG laser, 2.94 microm/100 mJ/10 Hz/30 seconds; group B: diode laser, 810 nm/1.0 W/0.05 ms/30 seconds; group C: diode laser, 810 nm/1.4 W/0.05 ms/30 seconds. The temperature was monitored by means of a type T thermocouple (copper-constantan) positioned in the pulp chamber to assess pulpal temperature during and before irradiation. Afterwards, the specimens were longitudinally sectioned, and the buccal and lingual surfaces of each root were analyzed by scanning electron microscopy. RESULTS: In the Er:YAG laser group, the thermal analysis revealed an average temperature of -2.2 +/- 1.5 degrees C, while in the diode laser groups, temperatures were 1.6 +/- 0.8 degrees C at 1.0 W and 3.3 +/- 1.0 degrees C at 1.4 W. Electronic micrographs revealed that there were no significant morphological changes, such as charring, melting, or fusion, in any group, although the specimens were found to be more irregular in the Er:YAG laser group. CONCLUSIONS: The application of Er:YAG and diode lasers at the utilized parameters did not induce high pulpal temperatures. Root surface irregularities were more pronounced after irradiation with an Er:YAG laser than with a diode laser.

PMID: 12886994 [PubMed - indexed for MEDLINE]
Influence of an Er:YAG laser on the surface structure of titanium implants

[Article in French, German]

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In addition to conventional treatment modalities (mechanical and chemical), the use of lasers has been proposed for cleaning and detoxification of implant surfaces. The aim of the present clinical investigation was (1) to evaluate the effects of an Er:YAG laser on the surface properties of titanium implants in vivo and (2) to determine the effectiveness of this treatment modality for subgingival calculus removal. This investigation was conducted on eight implants of two patients, considered for explantation due to severe peri-implantitis inflammation. Immediately before explantation, six implants were instrumented subgingivally with an Er:YAG laser (100 mJ/pulse and 10 Hz). Two implants served as a control. All titanium implants were examined using scanning electron microscopy by one calibrated and blinded examiner. In comparison to the untreated control group, non-surgical instrumentation of titanium implants with an Er:YAG laser resulted in an effective removal of subgingival calculus without leading to any thermal damages. However, all samples of the test group revealed amounts of residual debris which should be taken into account under clinical conditions.

Publication Types:

- Clinical Trial
- Controlled Clinical Trial

PMID: 12872590 [PubMed - indexed for MEDLINE]
Microleakage of composite resin restoration in cavities prepared by Er:YAG laser irradiation in primary teeth.

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AIM: The purposes of this study were to investigate the surface morphology of cavities prepared by Er:YAG laser irradiation and to compare the microleakage degree after composite resin restoration with etched bur cavities in primary teeth, in vitro. MATERIALS AND METHODS: On the buccal (facial) and lingual (palatal) surfaces of 25 primary teeth, a round cavity was prepared with the Er:YAG laser system and with a high-speed diamond bur, respectively. Five cavities from each group were investigated by scanning electron microscopy (SEM). The remaining cavities were filled with a composite resin and subjected to a microleakage test (0.6% rodamine B solution) under thermocycling. Only bur cavities were acid-etched before filling. Statistical analysis was performed using the Mann-Whitney's U test; a value of p < 0.01 was considered significant. RESULTS: SEM observation of the laser and etched bur cavities revealed an absence of a smear layer; enamel rods and opening of dentinal tubules were recognized. No statistically significant differences were noted between microleakage of composite resin restorations of the laser and the etched bur cavities. Crosscut sections of the cavities with no microleakage showed good adhesion between the restorative material and dental hard tissues; there was also no gap at the interface. DISCUSSION: The highly irregular surface or the removal of the debris-like smear layer after laser irradiation may facilitate good adhesion of composite resin with enamel or dentine, and these surfaces might play a major role in decreasing microleakage of laser cavities. CONCLUSION: It can be concluded that cavities prepared by Er:YAG laser are capable of decreasing microleakage of composite resin restorations in primary teeth, and the efficiency is similar to etched bur cavities.

PMID: 12871016 [PubMed - in process]
Clinical application of Er:YAG laser for cavity preparation in children.

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OBJECTIVE: The purpose of this study was to determine the clinical usefulness of Er:YAG laser for cavity preparation in children. BACKGROUND DATA: The conventional methods for cavity preparation instill fear and discomfort in pediatric patients. The Er:YAG laser is a new tool developed for cavity preparation; however, there are few reports of its clinical application. MATERIALS AND METHODS: A clinical evaluation using an Er:YAG laser was carried out using 32 subjects (with 16 deciduous and 19 permanent teeth) with ages ranging from 2 to 12 years. All cavities were restored with light-cured composite resin following the application of bonding agent, but without acid etching or primer conditioning. RESULTS: During laser treatment, the pediatric patients were very cooperative and hardly complained of any pain, and no tooth showed undesirable effects during the 3-year period of observation. CONCLUSION: It can be concluded from the results of this study that an Er:YAG laser would be a useful alternative method for cavity preparation for composite resin restoration in children.

PMID: 12828850 [PubMed - indexed for MEDLINE]
Effects of water flow on dental hard tissue ablation using Er:YAG laser.

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OBJECTIVE: The aim of this study was to investigate the effect of water on dental hard tissue ablation using Er:YAG laser as it relates to energy and pulse repetition rate, and determine the water flow rate that produces the most effective ablation at a given irradiation condition. BACKGROUND DATA: Er:YAG laser application leads to volumetric expansion and micro-explosions that result in hard tissue ablation. Ablation efficiency is improved when combined with fine water spray. MATERIALS AND METHODS: Extracted, healthy human molars were sectioned into two pieces and categorized into small groups related to water flow rate (1.69, 6.75, and 13.5 mL/min), pulse energy (250 and 400 mJ), and pulse repetition rate (5, 10, and 20 Hz). Within the combination of irradiation parameters, a laser beam was applied over enamel and dentin surfaces of the specimens, and the ablation amount was determined by differences in weight before and after irradiation. RESULTS: At a pulse energy of 250 mJ, the most effective ablation resulted from a water flow rate of 1.69 mL/min in both enamel and dentin. With 400 mJ/pulse, dentin removal was most effective at the water flow rate of 1.69 mL/min, whereas the efficiency of enamel ablation was the highest at 6.75 mL/min. Dental hard tissue ablated better as energy and pulse repetition rate increased. CONCLUSION: Effective ablation of dental hard tissue using Er:YAG laser requires that the appropriate water flow rate correspond properly to irradiation conditions. The results of this study suggest the following parameters; a water flow rate of 1.69 mL/min for enamel and dentin ablation at a pulse energy of 250 mJ and for dentin ablation at 400 mJ/pulse, and a water flow rate of 6.75 mL/min for enamel ablation at a pulse energy of 400 mJ, regardless of pulse repetition rate of 5, 10, and 20 Hz.

Publication Types:

- Evaluation Studies

PMID: 12828848 [PubMed - indexed for MEDLINE]
Effect of Er:YAG laser and EDTAC on the adhesiveness to dentine of different sealers containing calcium hydroxide.

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AIM: To evaluate the effect of 15% EDTAC solution and Er:YAG laser irradiation on the adhesiveness to dentine of root canal sealers containing calcium hydroxide. METHODOLOGY: The crowns of 60 maxillary human molars were ground until dentine was exposed. The teeth were divided into three groups of 20 teeth: group I, the dentine surface received no treatment; group II, 15% EDTAC solution was applied to the dentine; group III, the dentine received Er:YAG laser application (11 mm focal distance with perpendicular incidence to dentine surface; 4 Hz frequency; 200 mJ energy; 2.25 W potency; 62 J total energy; 1 min application time). Aluminium cylinders filled with the sealers, Sealer 26, Apexit, Sealapex and CRCS, were then applied to the treated surfaces. Adhesiveness was measured with a universal testing machine, with traction results given in MegaPascals (MPa). These results were submitted to anova tests. RESULTS: Statistical analysis showed significant differences (P < 0.01) amongst adhesiveness values of the sealers and treatments tested. Thus, sealers could be ranked in decreasing adhesiveness values: Sealer 26, CRCS, Apexit, Sealapex. Er:YAG laser irradiation and EDTAC solution application increased adhesiveness values only for Sealer 26 and Apexit. Laser irradiation was superior to EDTAC application only for Sealer 26 adhesiveness values. CONCLUSIONS: Er:YAG laser is as efficient as EDTAC solution in increasing adhesiveness of root canal sealers containing calcium hydroxide to human dentine.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

PMID: 12823702 [PubMed - indexed for MEDLINE]
Periodontal treatment with an Er:YAG laser or scaling and root planing. A 2-year follow-up split-mouth study.

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BACKGROUND: Non-surgical periodontal treatment with an Er:YAG laser has been shown to result in significant clinical attachment level gain; however, clinical results have not been established on a long-term basis following Er:YAG laser treatment. Therefore, the aim of the present study was to present the 2-year results following non-surgical periodontal treatment with an Er:YAG laser or scaling and root planing.

METHODS: Twenty patients with moderate to advanced periodontal destruction were treated under local anesthesia, and the quadrants were randomly allocated in a split-mouth design to either 1) Er:YAG laser (ERL) using an energy level of 160 mJ/pulse and 10 Hz, or 2) scaling and root planing (SRP) using hand instruments. The following clinical parameters were evaluated at baseline and at 1 and 2 years after treatment: plaque index (PI), gingival index (GI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR), and clinical attachment level (CAL). Subgingival plaque samples were taken at each appointment and analyzed using dark-field microscopy for the presence of cocci, non-motile rods, motile rods, and spirochetes. The primary outcome variable was CAL. No statistically significant differences between the groups were found at baseline. Power analysis to determine superiority of ERL treatment showed that the available sample size would yield 99% power to detect a 1 mm difference. RESULTS: The sites treated with ERL demonstrated mean CAL change from 6.3 +/- 1.1 mm to 4.5 +/- 0.4 mm (P < 0.001) and to 4.9 +/- 0.4 mm (P < 0.001) at 1 and 2 years, respectively. No statistically significant differences were found between the CAL mean at 1 and 2 years postoperatively. The sites treated with SRP showed a mean CAL change from 6.5 +/- 1.0 mm to 5.6 +/- 0.4 mm (P < 0.001) and to 5.8 +/- 0.4 mm (P < 0.001) at 1 and 2 years, respectively. The CAL change between 1 and 2 years did not present statistically significant differences. Both groups showed a significant increase of cocci and non-motile rods and a decrease in the amount of spirochetes. However, at the 1- and 2-year examination, the statistical analysis showed a significant difference for the CAL (P < 0.001, respectively) between the 2 treatment groups. CONCLUSION: It was concluded that the CAL gain obtained following non-surgical periodontal treatment with ERL or SRP can be maintained over a 2-year period.

PMID: 12816290 [PubMed - indexed for MEDLINE]
Cavity preparation by Er-YAG laser on pulpal temperature rise.

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PURPOSE: To measure the intrapulpal temperature changes in vitro, during cavity preparation and caries removal, using the Opus 20 Er-YAG laser plotted as a function of the laser energy and pulse rate. MATERIALS AND METHODS: Class I and V cavity preparations were made in 175 fresh extracted caries-free human teeth and caries removal was carried out in 42 carious extracted teeth by the Opus 20 Er-YAG laser. K-type thermocouples were inserted into the pulp chambers filled with heat conducting paste. Lasing was carried out at different irradiation energies and pulse frequencies, using air-water spray. Temperature changes in the pulp chamber were measured during lasing. RESULTS: In all groups tested, the maximum temperature rise was lower than 5.5 degrees C, which is considered as critical value for pulp vitality. The highest temperature values were measured during Cl I preparations (3.13 degrees C +/- 1.54 - 4.11 degrees C +/- 1.29), medium values were in Cl V in enamel (2.38 degrees C +/- 1.37 - 4 degrees C +/- 1.07) and the lowest were in cementum (2.10 degrees C +/- 0.61 - 3.61 degrees C +/- 1.15) and during caries removal (1.21 degrees C +/- 0.46 - 3.51 degrees C +/- 0.68).

PMID: 12797566 [PubMed - indexed for MEDLINE]
Efficacy of subgingival calculus removal with Er:YAG laser compared to mechanical debridement: an in situ study.

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OBJECTIVES: The aim of the present study was to compare the effectiveness of subgingival calculus removal from periodontally involved root surfaces with an Er:YAG laser compared to hand instrumentation in situ. METHODS: The mesial and distal surfaces of 30 single-rooted teeth with untreated periodontitis were treated either by hand instrumentation (scaling and root planing (SRP)) or by Er:YAG laser irradiation with the aim of achieving a calculus-free root surface. Subgingival plaque samples were obtained before and immediately after treatment for microbiological evaluation by culture and DNA probe analysis. The teeth were extracted and the residual calculus was measured by means of digitized planimetry. The morphology of the root surface was evaluated by scanning electron microscopy, and undecalcified sections were analyzed to determine residual calculus and the extent of cementum removal following both treatments. RESULTS: Following laser irradiation, 68.4 +/-14.4% of the root surface was calculus free in contrast to 93.9 +/-3.7% after SRP when both treatments were performed for the same time (2:15 +/-1:00 min). If laser irradiation was allowed twice the time used for hand instrumentation, 83.3 +/-5.7% of the root surface was devoid of calculus. The effectiveness of both treatments was not related to initial probing depth. The histologic evaluation showed that after SRP 73.2% of root dentin was completely denuded from cementum, while only a minimal cementum reduction was apparent after laser irradiation. Both treatment modalities resulted in a similar reduction of periodontopathogens. DISCUSSION: The present investigation could demonstrate the in vivo capability of the Er:YAG laser to remove calculus from periodontally involved root surfaces, although the effectiveness did not reach that achieved by hand instrumentation. The lack of cementum removal in contrast to SRP may qualify the laser as an alternative approach during supportive periodontal therapy.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

PMID: 12795789 [PubMed - indexed for MEDLINE]
Electron probe micro-analysis of a contact probe after Er:YAG laser tooth ablation.

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The purpose of this study was to investigate the contact probes of Er:YAG laser before and after tooth ablation. Three kinds of contact probe were prepared. The first was an unused probe (NE). The second was used to prepare 10 cervical cavities (KP). The third was a probe that was judged for an exchange by three dentists who had expertise with Er:YAG laser (EX). The surface observation and mapping analysis were performed. The contact surface of NE was a flat and smooth surface, only Si was observed. KP demonstrated an uneven surface, Si was observed throughout, with scattered indications of Ca and P. EX displayed regions of fracture along the edge and a surface exhibiting dissolved adherents in parts. It was suggested that micro-explosions have effects on not only the tooth substance, but also the contact surface of the probe.

PMID: 12790299 [PubMed - indexed for MEDLINE]
In vivo and in vitro effects of an Er:YAG laser, a GaAlAs diode laser, and scaling and root planing on periodontally diseased root surfaces: a comparative histologic study.

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BACKGROUND AND OBJECTIVES: The aim of the present histologic study was to compare the in vivo and in vitro effects of an erbium: yttrium, aluminum, and garnet (Er:YAG) laser (ERL), combined with a fluorescent calculus detection system, a diode laser (DL) and scaling and root planing (SRP) on periodontally diseased root surfaces.

STUDY DESIGN/MATERIALS AND METHODS: Twenty-four single rooted teeth, considered for extraction due to severe periodontal destruction, were included in the study. Prior to extraction all mesial root surfaces were randomly assigned to the following treatment groups: (1) ERL combined with a calculus detection system with fluorescence induced by 655 nm InGaAsP DL radiation (160 mJ/pulse and 10 pulses/second under water irrigation) (ERL), or (2) GaAlAs DL (1.8 W, pulse/pause relation 1:10), or (3) SRP using hand instruments. Immediately after extraction, all distal root surfaces were treated with the same instruments under standardized conditions. For light microscopic investigation, a plastic embedding technique was used to cut the undecalcified roots into 30 microm thick crossections. The following parameters were recorded by on blind examiner: remaining debris, root surface morphology, and thermal side effects.

RESULTS: Root surfaces instrumented with both, ERL in vivo and DL in vitro exhibited no detectable surface alterations. In contrast, ERL scaling in vitro and SRP in vivo/in vitro produced superficial microchanges in root cementum. However, irradiation with DL in vivo caused severe damages to the root surface (i.e., crater formation). There were no signs of thermal side effects in all laser treated groups. ERL provided subgingival calculus removal on a level equivalent to that provided by SRP. DL was unsuitable for calculus removal, since macroscopic inspection revealed the presence of large amounts of subgingival calculus.

CONCLUSIONS: The present in vivo results showed that (i) ERL, combined with a fluorescent calculus detection system, provided a selective subgingival calculus removal on a level equivalent to that provided by SRP, and (ii) DL, using this power output, was unsuitable for calculus removal and altered the root surface in an undesirable manner. Copyright 2003 Wiley-Liss, Inc.

PMID: 12766958 [PubMed - indexed for MEDLINE]
Removal of bacterial endotoxin from root surface with Er:YAG laser.

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PURPOSE: To determine the potential of 2.94 microm Er:YAG laser radiation to remove bacterial endotoxin from root surfaces. MATERIALS AND METHODS: 40 extracted teeth were divided into four groups of 10 samples each. A 16 mm2 area of the root surface on each sample was inoculated with an aliquot of 7 microl of a lipopolysaccharide suspension at a concentration of 50 IU/ml. LPS was derived from a non-oral Escherichia coli strain (E. coli 055:B5). Source of laser radiation was an Er:YAG laser emitting pulsed infrared radiation at a wavelength of 2.94 microm, with a pulse duration of 250 micros, and a pulse repetition rate of 15 pps. Three specimen groups were irradiated with 105 laser pulses at a radiation energy of 60 mJ, 100 mJ and 140 mJ. One specimen group was untreated (control). The LPS concentration with each sample was determined using a chromogenic, quantitative Limulus-amoeocyte-lysate assay. Statistical analysis was ANOVA and Scheffe-test. RESULTS: Mean LPS yield from the untreated control samples was 50.1 (+/- 35.9) IU/ml. Following laser irradiation the average LPS on the root surfaces was 19.86 (+/- 14.4) IU/ml at 60 mJ, 12.86 (+/- 8.1) IU/ml at 100 mJ and 8.58 (+/- 4.9) IU/ml at 140 mJ.

PMID: 12744404 [PubMed - indexed for MEDLINE]
Influence of the frequency of Er:YAG laser on the bond strength of dental enamel.

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OBJECTIVE: The present study had the aim of evaluating the influence of different frequencies of the Er:YAG laser on adhesive resistance of enamel and one restorative system. Background Data: There have been no reports of studies assessing the influence of the pulse frequency variation of the Er:YAG laser on adhesive resistance of the enamel/resin interface. MATERIALS AND METHODS: Fifty surfaces of enamel from extracted human third molars were planed and divided into five groups at random. Enamel surface treatment was realized by the Er:YAG laser at 80-mJ power and 1-, 2-, 3-, and 4-Hz pulse frequencies, followed by etching. For the control group, only acid conditioning with 37% phosphoric acid for 15 sec was used. The Single Bond/Filtek Z250 system was chosen for the fabrication of the specimens, which were stored in 100% relative humidity for 24 h, at 37 degrees C. The specimens were submitted to tensile resistance tests using a Universal Testing Machine (50 Kgf and 0.5 mm/min). RESULTS: The mean values in MPa were 1 Hz, 25.58 (+/-6.16); 2 Hz, 25.58 (+/-3.79); 3 Hz, 21.34 (+/-3.78); 4 Hz, 21.17 (+/-3.13); and phosphoric acid only, 22.44 (+/-7.0). Data were submitted to statistical analysis using ANOVA, and there was no significant difference in tensile resistance between the studied groups. CONCLUSION: The results suggest that the Er:YAG laser, with 80-mJ power associated with acid conditioning at 1-, 2-, 3-, and 4-Hz frequencies, did not present significant improvement in tensile bonding of enamel, as compared to acid conditioning only.

PMID: 12737651 [PubMed - indexed for MEDLINE]
Preparation of root canal orifices by Er:YAG laser irradiation: in vitro and clinical observations.

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OBJECTIVE: The purpose of the present study was to evaluate the effectiveness of Er:YAG laser irradiation for preparation of root canal orifices in extracted human teeth and several clinical cases.

Background Data: Few studies with sufficient data have been conducted in this area.

MATERIALS AND METHODS: Orifices of 42 extracted human teeth were prepared by conventional methods using a Peeso reamer or Er:YAG laser device at 250 mJ/pulse and 8 Hz. In the clinical study, the orifices of 11 teeth from 11 patients with irreversible pulpitis were prepared by Er:YAG laser irradiation at 160 mJ/pulse and 8 Hz. Teeth were carefully irradiated using non-contact methods. Evaluation was performed by visual inspection, stereoscopy, radiography, and scanning electron microscopy (SEM). In addition, the efficiency of using the Er:YAG laser was evaluated.

RESULTS: In the in vitro study, canal orifices were clearly exposed by laser irradiation in all specimens. In 31 of 36 teeth (86%), orifices were successfully prepared without ledge formation or perforation. SEM observations revealed that irradiated surfaces were slightly rough and scaly, but essentially free from debris and smear layer. In the clinical study, orifices were successfully prepared in 10 of 11 teeth (91%), and no ledge formation or perforation was observed.

CONCLUSION: These results suggest that the preparation of root canal orifices by Er:YAG laser irradiation may be useful in most cases, if appropriate parameters are selected.

PMID: 12737648 [PubMed - indexed for MEDLINE]
Effects of 2.94 microm Er:YAG laser radiation on root surfaces treated in situ: a histological study.

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BACKGROUND: Previous scanning electron microscopy (SEM) studies using extracted teeth have shown the potential of infrared Er:YAG laser radiation to remove subgingival calculus without causing severe thermal changes, e.g., charring or fusion, to the irradiated root surface. The purpose of the present study was to examine the morphologic changes on root surfaces following Er:YAG laser irradiation in situ using histological observation. METHODS: The periodontal pockets of 6 premolars, canines, and incisors that remained in situ in the jaws of human corpses were irradiated with Er:YAG laser radiation at 60 mJ, 100 mJ, or 180 mJ. The pockets were treated in a similar manner to normal clinical circumstances with a total amount of either 50 or 100 laser pulses. Following laser treatment, the entire tooth, marginal gingiva, and underlying alveolar bone were removed from the jaw. The sections were embedded in methyl-methacrylate, serially cross-sectioned, stained with hematoxylin and eosin or gallamine blue, and examined under a light microscope. Additionally, the extension of the thermally changed tissue areas was determined using digital images and histometry. RESULTS: The histological examination revealed two kinds of thermal changes within the hard tissue bordering the periodontal pocket. Firstly, a thin superficial layer 5 to 10 microm in width was observed. The surface of this layer showed ultrastructural irregularities. Secondly, a semicircular more deeply stained area close to the apical end of the scaling track beneath the irradiated cementum was observed. The depth of this area ranged from 255 microm to 611 microm and appeared to be independent of the radiation energy. CONCLUSION: In contrast to previous SEM studies, the histological examination indicated thermal changes within the hard tissue bordering the periodontal pocket following Er:YAG laser irradiation.

PMID: 12710756 [PubMed - indexed for MEDLINE]

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OBJECTIVES: The purpose of the present controlled clinical trial was to compare the treatment of advanced periodontal disease with a combination of an Er:YAG laser (KEY II, KaVo, Germany) and scaling and root planing with hand instruments (SRP) to laser alone. MATERIAL AND METHODS: Twenty healthy patients with moderate to advanced periodontal destruction were randomly treated in a split-mouth design with a combination of an Er:YAG laser and SRP (test) or with laser (control) alone. The used energy setting for laser treatment was 160 mJ/pulse at a repetition rate of 10 Hz. Prior to treatment and 3, 6 and 12 months later the following parameters were evaluated by a blinded examiner: Plaque index (PI), gingival index (GI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR) and clinical attachment level (CAL). Subgingival plaque samples were taken at each appointment and analysed using darkfield microscopy for the presence of cocci, non-motile rods, motile rods and spirochetes. No statistical significant differences in any of the investigated parameters between both groups were observed at baseline. RESULTS: Initially, the plaque index was 1.0 +/- 0.6 in both groups. At the 3-month examination the plaque scores were markedly reduced and remained low throughout the study. A significant reduction of the GI and BOP occurred in both groups after 3, 6 and 12 months (P < 0.05, P < 0.05, respectively). The mean PD decreased in the test group from 5.2 +/- 0.8 mm at baseline to 3.2 +/- 0.8 mm after 12 months (P < 0.05) and in the control group from 5.0 +/- 0.7 mm at baseline to 3.3 +/- 0.7 mm after 12 months (P < 0.05). The mean CAL decreased in the test group from 6.9 +/- 1.0 mm at baseline to 5.3 +/- 1.0 mm after 12 months (P < 0.05) and in the control group from 6.6 +/- 1.1 mm at baseline to 5.0 +/- 0.7 after 12 months (P < 0.05). Both groups showed a significant increase of cocci and non-motile rods and a decrease in the amount of motile rods and spirochetes. Conclusion: In conclusion, the present results have indicated that: (i) non-surgical periodontal therapy with both an Er:YAG laser + SRP and an Er:YAG laser alone may lead to significant improvements in all clinical parameters investigated, and (ii) the combined treatment Er:YAG laser + SRP did not seem to additionally improve the outcome of the therapy compared to Er:YAG laser alone.

Publication Types:
PMID: 12702108 [PubMed - indexed for MEDLINE]
Root surface roughness following Er:YAG laser irradiation at different radiation energies and working tip angulations.

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OBJECTIVES: The determination of roughness of root surfaces following treatment with 2.94 μm Er:YAG laser radiation at different radiation energies and working tip angulations. MATERIALS AND METHODS: The study sample comprised 85 extracted human molars, premolars, canines and incisors (n = 85). The source of laser radiation was an Er:YAG laser device (KAVO-Key II, System Aesculap Meditec) emitting pulsed infrared radiation at a wavelength of 2.94 μm, with a pulse duration of 250 μs, and a pulse repetition rate of 10 pps. The samples were randomly divided into three experimental units, for treatment with a constant amount of 380 laser pulses at a radiation energy of 60 mJ, 100 mJ, and 180 mJ. Each experimental unit was divided into five subgroups of five samples, which were irradiated at a working tip angulations of 15 degrees, 30 degrees, 45 degrees, 60 degrees, and 90 degrees. Five samples were treated mechanically using curettes. Five samples were left untreated as control. The mean (Ra) and maximum (Rmax) surface roughness of each sample was measured using a profilometer. The statistical analysis was undertaken using anova and Scheffe-test at a level of significance of 5% (p < 0.05). RESULTS: Er:YAG laser radiation led to an Ra which ranged from 0.52 μm (+/- 0.10) to 0.81 μm (+/- 0.26) and to an Rmax between 3.4 μm (+/- 0.48) and 9.26 μm (+/- 3.08). The Ra and Rmax for samples treated with curettes was 0.51 μm (+/- 0.11) and 5.08 μm (+/- 4.98), respectively. That for the untreated control samples were 0.53 μm (+/- 0.15) and 7.07 μm (+/- 5.48), respectively. CONCLUSIONS: The mean and maximum surface roughness of root surfaces following irradiation with Er:YAG laser was not significantly different to that obtained on samples treated with conventional hand instruments or left untreated. Furthermore, the surface roughness does not depend on the radiation energy and the angulation of the working tip.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

PMID: 12354084 [PubMed - indexed for MEDLINE]
Desensitizing effects of an Er:YAG laser on hypersensitive dentine.

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AIM: The aim of the present study was to evaluate and compare the desensitizing effects of an Er:YAG laser (KEY II(R), KaVo, Germany) and Dentin Protector (Vivadent, Germany) on cervically exposed hypersensitive dentine. METHOD: A group of 30 patients showing a total of 104 contralateral pairs of hypersensitive and caries-free teeth was selected and randomly allocated in a split-mouth design to either (1) Er:YAG laser (80 mJ/pulse, 3 Hz), or (2) the application of Dentin Protector (polyurethane-isocyanate 22.5%; methylenechloride 77.5%) whereat one pair served as an untreated control in each patient. The degree of sensitivity to a thermal stimulus was determined qualitatively with an evaporative stimulus defined as a 3-s air blast at a distance of 2 mm from each site to be tested. A qualitative registration of the degree of discomfort was determined according to an arbitrary pain scale in 4 degrees. Recordings were assessed before treatment, immediately after, 1 week, 2 and 6 months after treatment by 1 blinded examiner. RESULTS: Both treatment forms resulted in significant improvements of discomfort immediately after and 1 week post treatment. After 2 months, the discomfort in the Dentin Protector(R) group increased up to 65% of the baseline score and even up to 90% after 6 months, whereas the effect of the laser remained at the same level that was achieved immediately after treatment. The differences immediately after, 1 week, 2 and 6 months post treatment between both groups were statistically high significant (p< or =0.001; respectively). Compared to the untreated control group, both treatment forms resulted in a significant reduction of discomfort at each follow-up examination. CONCLUSION: It was concluded that desensitizing of hypersensitive dentine with an Er:YAG laser is effective and the maintenance of the positive result was more prolonged than with Dentin Protector.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

PMID: 11940139 [PubMed - indexed for MEDLINE]
Evaluation of dentin root canal permeability after instrumentation and Er:YAG laser application.

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BACKGROUND AND OBJECTIVES: Smear layer removal with EDTA from root canal walls allows greater cleaning and disinfection of root canals. However, because Er:YAG laser acts on the removal of the smear layer, the objective of investigation was to analyze in vitro the effect of Er:YAG laser on dentin root canal wall permeability after endodontic instrumentation and irrigation with water or sodium hypochlorite and Er:YAG laser application. STUDY DESIGN/MATERIALS AND METHODS: A total of 25 extracted human maxillary incisors were divided into five groups: Group I, instrumentation with deionized distilled water as the irrigating solution; Group II, instrumentation with 1% sodium hypochlorite as the irrigating solution; Group III, instrumentation with deionized distilled water as the irrigating solution and Er:YAG laser application; Group IV, instrumentation with 1% sodium hypochlorite solution as the irrigating solution and Er:YAG laser application; Group V, instrumentation only up to #20 file with deionized distilled water as the irrigating solution and Er:YAG laser irradiation. The laser parameters were 15 Hz, 140 mJ, total energy 42 J, 300 pulses (Kavo Key Laser). Copper sulfate (10%) was used to evaluate dentin permeability. The penetration of copper ions into the dentinal tubules was observed using 1% rubeanic acid, which reveals copper ions, forming a stained compound ranging in color from deep blue to black. Transverse sections (500-microm thick) were obtained with a diamond disk from the cervical, middle, and apical thirds. RESULTS: The instrumentation of the root canal that used water as the irrigating solution followed by Er:YAG laser irradiation promoted the greatest increase in dentin permeability. The use of Er:YAG laser, 1% sodium hypochlorite + Er:YAG, and 1% sodium hypochlorite used alone showed an intermediate capacity of increasing dentin permeability. The use of water as the irrigating solution without Er:YAG laser promoted the least dentin permeability. CONCLUSIONS: The use of water as the irrigating solution after instrumentation and Er:YAG laser irradiation was an effective procedure for increasing dentin permeability. Copyright 2000 Wiley-Liss, Inc.

PMID: 10738290 [PubMed - indexed for MEDLINE]
SEM evaluation of the interaction pattern between dentin and resin after cavity preparation using ER:YAG laser.

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Objective. The aim of this study was to describe the interaction pattern formed between dentin and resin on cavities prepared with an erbium laser (Er:YAG). The morphological aspect of the irradiated dentin after acid etching was also observed.

Methods. Ten dentin disks were obtained from fresh extracted third molars. Each disk received two cavities, one prepared with a conventional high-speed drill, while the other cavity was obtained by the use of an Er:YAG laser (KaVo KEY Laser, KaVo Co.). The laser treatment was performed with 250mJ/pulse, 4Hz, non contact mode, focused beam, and a fine water mist was used. Five disks were prepared for morphological analysis of the acid etched dentin. The other five disks had their cavities restored with Single Bond (3M) followed by Z100 resin (3M). The specimens were observed under scanning electron microscopy after dentin-resin interface demineralization and deproteinization.

Results and conclusions. It was observed that the morphological characteristics of the acid-etched irradiated dentin were not favorable to the diffusion of monomers through the collagen network. The dentin-resin interfacial aspect of irradiated dentin, after acid etching, showed thin tags and scarce hybridization zones, which agreed with the morphology of the irradiated and acid-etched dentin substrate observed.

PMID: 12654552 [PubMed - as supplied by publisher]
Effect of Er:YAG laser on adhesion of root canal sealers.

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This in vitro study evaluated the effect of Er:YAG laser on adhesion to human dentin of Grossman, Endomethasone, N-Rickert, and Sealer 26 root canal sealers. The crowns of 40 human molars were cut on the occlusal side until a flat dentin surface was obtained. The teeth were divided into two groups: group 1, no laser application; and group 2, irradiation with Er:YAG laser (KaVo Key Laser 2; 11 mm focal distance, perpendicular to the dentin surface, 4 Hz frequency, 200 mJ energy, 62 J total energy and 313 pulses, 1-min application time, and 2.25 W power). Five samples were tested for each sealer and each group. An Instron universal testing machine was used for the adhesion test. Sealer 26 showed the best adhesion both with and without laser application (p < 0.01). Grossman and N-Rickert sealers had intermediate values, and Endomethasone had the worst adhesion. Application of Er:YAG laser did not alter the adhesion of Grossman, N-Rickert, or Endomethasone sealers. However, laser application increased the adhesion of Sealer 26. The epoxy resin-based root canal sealer (Sealer 26) adhered better to dentin prepared with and without Er:YAG laser than the zinc oxide/eugenol-based sealers (Endomethasone, N-Rickert, and Grossman).

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Microleakage and nanoleakage: influence of laser in cavity preparation and dentin pretreatment.

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OBJECTIVE: The purpose of this study was to verify if the application of the Nd:YAG laser following pretreatment of dentin with adhesive systems that were not light cured in class V cavities and were prepared with Er:YAG laser would promote better sealing of the gingival margins when compared to cavities prepared the conventional way.

BACKGROUND DATA: Previous studies had shown that the pretreatment of dentin with laser irradiation after the application of an adhesive system is efficient in achieving higher shear bond and tensile bond strength.

MATERIALS AND METHODS: Er:YAG laser (Kavo-Key, Germany) with 350 mJ, 4 Hz, and 116.7 J/cm² was used for cavity preparation. The conventional preparation was made with diamond bur mounted in high-speed turbine. Dentin treatment was accomplished using an Nd:YAG laser (Pulse Master 1000, ADT. USA) at 60 mJ, 10 Hz, and 74.65/cm² following application of the adhesive system. The cavities were stored with Single Bond/Z100 and Prime & Bond NT/TPH. Eighty bovine incisors were used, and class V preparations were done at buccal and lingual surfaces divided into eight groups: (1) Er:YAG preparation + Prime & Bond NT + TPH; (2) Er:YAG preparation + Single Bond + Z100; (3) Er:YAG preparation + Single Bond + Nd:YAG + Z100; (4) Er:YAG preparation + Prime & Bond NT + Nd:YAG + TPH; (5) conventional preparation + Prime & Bond NT + TPH; (6) conventional preparation + Single Bond + Z100; (7) conventional preparation + Single Bond + Nd:YAG + Z100; (8) conventional preparation + Prime & Bond NT + Nd:YAG + TPH. All specimens were thermocycled for 300 full cycles between 5 degrees C+/-2 degrees C and 55 degrees C+/-2 degrees C (dwell time of 30 sec), and stored in 50% silver nitrate solution for 24 h soaked in photodeveloping solution and exposed to fluorescent light for 6 h. After this procedure, the specimens were sectioned longitudinally in 3 portions and the extension of microleakage at the gingival wall was determined following a criteria ranging from 0 to 4 using scanning electron microscopy (SEM). The medium portion sectioned of each specimen was polished and prepared for nanoleakage assessment by SEM.

RESULTS: Kruskall-Wallis and Miller statistical tests determined that group 3 presented less microleakage and nanoleakage.

CONCLUSION: Application of the Nd:YAG laser following pretreatment of dentin with adhesive Single Bond non-photocured Single Bond adhesive in cavities prepared with Er:YAG promote better sealing of the gingival margins.

PMID: 11776451 [PubMed - indexed for MEDLINE]
Many lasers are available today for clinical application in dentistry. For the removal of caries in enamel or dentin only few lasers can be used. Er:YAG lasers have a wavelength that coincides with the absorption maximum of water. Because of this characteristic the ablative effect in enamel and dentin is high and these lasers can be used beneficially for caries removal and small preparations. The possible side effects of Er:YAG lasers with water-cooling are minor compared to those of rotary instruments. A pulpal reaction will occur only if there is a very thin dentin layer over the pulp or direct application of the laser beam to the pulp. There is no increased heating with the Er:YAG laser so with vital teeth there is a positive reaction by the formation of reparative dentin. To the existing indications for lasers like caries removal and preparation of small cavities, in the future new techniques can be added like the use of dyes for enhancement of absorption of the laser radiation, and minimal invasive techniques using feedback from a system for caries detection.

Publication Types:

- Review
- Review, Tutorial

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Bonding to Er-YAG-laser-treated dentin.

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Er-YAG laser irradiation has been claimed to improve the adhesive properties of dentin. We tested the hypothesis that dentin adhesion is affected by Er-YAG laser conditioning. Superficial or deep dentin from human molars was: (a) acid-etched with 35% H3PO4; (b) irradiated with an Er-YAG laser (KaVo) at 2 Hz and 180 mJ, with water-cooling; and (c) laser- and acid-etched. Single Bond (3M ESPE) and Z100 composite (3M ESPE) were bonded to the prepared surfaces. After storage, specimens were tested in shear to failure. Bonded interfaces were demineralized in EDTA and processed for transmission electron microscopy. Two-way ANOVA revealed that conditioning treatment and interaction between treatment and dentin depth significantly influenced shear bond strength results. Acid-etching alone yielded shear bond strength values that were significantly higher than those achieved with laser ablation alone, or in combination with acid-etching. The Er-YAG laser created a laser-modified layer that adversely affects adhesion to dentin, so it does not constitute an alternative bonding strategy to conventional acid etching.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

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ER-YAG laser pretreatment effect on in vitro secondary caries formation around composite restorations.

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PURPOSE: This in vitro study determined if Er-YAG laser used instead of acid-etching influenced artificial secondary caries formation in enamel and root surfaces.

MATERIALS AND METHODS: Class V cavities were prepared in buccal and lingual surfaces of 10 extracted caries-free molars, with cervical margins in the root surface and occlusal margins in enamel. The specimens were randomly assigned to 2 groups: Group 1: Enamel and dentin etched with 35% phosphoric acid gel (Scotchbond 15s, rinse 10s; n=5 teeth with 2 cavities per specimen, 10 occlusal and 10 root surface margins at caries risk). Group 2: Enamel and dentin surfaces conditioned using a pulsed Er-YAG laser (KAVO) with 2.94 microm wavelength, 250 micros pulse duration, 300 mJ for enamel and 250 mJ for root surface pulse energy, 2 Hz repetition rate, and water cooling (n=5 teeth with 2 cavities per specimen, 10 occlusal and 10 root surface margins at caries risk). The cavity preparations were restored with a wet-bonding technique (Scotchbond 1 adhesive system) and a hybrid resin, light-cured composite (Z100, A3 shade), according to the manufacturer's instructions. Acid-resistant varnish was applied leaving the restoration and a 1 mm rim of adjacent surface enamel and root surface exposed. The specimens were thermocycled (5-50 degrees C, 500 cycles, dwell time 30s). Following artificial caries formation (2.2 mM calcium, 2.2 mM phosphate, 50 mM acetic acid, 5.0 mg/L fluoride, pH 4.25, 10 days), longitudinal sections (3/tooth, 30 occlusal and cervical caries risk sites per group) were taken for polarized light microscopic examination (water imbibition). Primary surface lesion depth and wall lesion frequency was determined and compared between groups (Student's t-test). RESULTS: Er-YAG laser irradiation resulted in a 56% reduction in primary enamel surface lesion depth (116 microm mean depth) when compared with the acid-etched group (263 microm mean depth), and a 39% decrease in root surface lesion depth (194 microm mean depth) compared with that (316 microm mean depth) for acid-etching pretreatment (P<0.05). Wall lesion frequency was similar (P>0.05) between treatment groups.

Publication Types:

- Clinical Trial
- Randomized Controlled Trial

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