[COMPRENDIUM OF PUBLISHED CLINICAL LITERATURE]

WATERLASE IPLUS, WATERLASE MD
5201385 Rev. B
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PERIODONTAL PROCEDURES

Cleared indications for use


ENDODONTIC PROCEDURES

Cleared indications for use


Part No. 5201385

SOFT TISSUE PROCEDURES

Cleared indications for use


RESTORATIVE PROCEDURES

FDA CLEARED INDICATIONS

USE OF WATERLASE IPLUS and MD IS INDICATED FOR:

- Class I, II, III, IV and V cavity preparation
- Caries removal
- Hard tissue surface roughening or etching
- Enameloplasty, excavation of pits and fissures for placement of sealants * For use on adult and pediatric patients
The impact of Er:Cr:YSGG laser on the shear strength of the bond between dentin and ceramic is dependent on the adhesive material

Barbara Cvikl · Gundula Moser · Jörg Wernisch · Modesto Raabe · Reinhard Gruber · Andreas Moritz

Received: 12 May 2011 / Accepted: 29 June 2011

Abstract The bond joint between dentin and ceramic is a critical determinant in prosthodontic dentistry. The laser is an alternative to the diamond bur for preparing tooth cavities. However, the impact of lasers on the bond between the laser-irradiated dentin and the ceramic remains a matter of controversy. We determined the shear strength of bonds between ceramic blocks and human dentin discs prepared with either an Er,Cr:YSGG laser or a diamond bur. A total of 180 dentin discs were randomly assigned to four groups. Three groups of discs were prepared with the Er,Cr:YSGG laser irradiation (2 W, 30 Hz, 50% H₂O, 70% air) and the fourth group was prepared with a diamond bur. In one of the laser groups the discs surfaces were also treated with phosphoric acid and in another with phosphoric acid and mechanical smoothing using a dental excavator. The ceramic blocks were bonded to the dentin discs with Syntac adhesive (together with Variolink II curing system), Excite adhesive (together with Variolink II curing system) or RelyX self-adhesive cement. The shear strength of the bond between ceramic and dentin was significantly higher following dentin surface treatment with the laser alone than following treatment with the diamond bur and Variolink II/Syntac (p = 0.021) but not significantly higher than following treatment with the diamond bur and Variolink II/Excite (p = 0.138) or RelyX (p = 0.150). A significant difference was not observed when the laser-treated dentin was conditioned with phosphoric acid and mechanical smoothing. These findings demonstrate that the bond between dentin and ceramic may be stronger after laser irradiation; however, the selection of the adhesive material is an additional factor that affects the bond strength.

Keywords Adhesive · Dentin · Er,Cr:YSGG laser · Prosthodontic therapy · Shear bond strength

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Part No. 5201385
Laser Profilometry for the Characterization of Craters Produced in Hard Dental Tissues by Er:YAG and Er,Cr:YSGG Lasers

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ABSTRACT:
A new, highly accurate and repeatable methodology based on the principle of optical triangulation to measure ablation rates in hard dental tissues is introduced. Using this methodology, a comparison is made between the two leading laser wavelengths for hard tissue procedures in dentistry, Er:YAG (Fidelis Plus III, Fotona) and Er,Cr:YSGG (Waterlase MD, Biolase). In-vitro measurements of the maximum available drilling speeds (ablated volume per second) revealed ablation rates of the Er:YAG laser system to be 3.7 times higher in dentine, and 5.0 times higher in enamel compared to those achieved with the Er,Cr:YSGG laser system.

Key words: Er:YAG; Er,Cr:YSGG; optical triangulation principle, VSP technology, ablation speed; hard tissue procedures.
Effect of different power parameters of Er,Cr:YSGG laser on human dentine

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Received: 20 June 2006 / Revised: 4 August 2006 / Accepted: 16 November 2006 / Published online: 23 January 2007

Abstract The aim of this work was to determine the optimal power setting of an Er,Cr:YSGG laser for cutting human dentine to produce a surface that remains suitable as a foundation on which to build and bond a dental restoration. The cutting efficiency and resulting microhardness of the dentine were evaluated for various laser power settings, and representative samples were examined by SEM. The microhardness of the dentine was significantly reduced by 30–50% (p < 0.05, paired t test) after laser irradiation, irrespective of the power setting used. The mean ablation efficiency increased in proportion to the power setting of the laser. Although the laser power setting did not affect the extent of reduction in microhardness, it did affect the microstructure of human dentine.

Keywords Er,Cr:YSGG laser · Microhardness · Laser irradiated dentine · Laser ablation · Dentine morphology

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Influence of etching time on bond strength in dentin irradiated with erbium lasers

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Abstract The purpose of this in vitro study was to evaluate the effect of etching time on the tensile bond strength (TBS) of a conventional adhesive bonded to dentin previously irradiated with erbium:yttrium–aluminum–garnet (Er:YAG) and erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) lasers. Buccal and lingual surfaces of 45 third molars were flattened until the dentin was exposed and randomly assigned to three groups (n = 30) according to the dentin treatment: control (not irradiated), irradiated with Er:YAG (1 W; 250 mJ; 4 Hz; 80.6 J/cm²) laser or Er,Cr:YSGG (4 W; 200 mJ; 20 Hz; 71.4 J/cm²) laser, and into three subgroups (n = 10) according to acid etching time (15 s, 30 s or 60 s) for each experimental group. After acid etching, the adhesive was applied, followed by the construction of an inverted cone of composite resin. The samples were immersed in distilled water (37°C for 24 h) and subjected to TBS test [50 kilogram-force (kgf), 0.5 mm/min]. Data were analyzed by analysis of variance (ANOVA) and Tukey statistical tests (P ≤ 0.05). Control group samples presented significant higher TBS values than those of all lased groups. Both irradiated groups exhibited similar TBS values. Samples subjected to the different etching times in each experimental group presented similar TBS. Based on the conditions of this in vitro study we concluded that Er:YAG and Er,Cr:YSGG laser irradiation of the dentin weakens the bond strength of the adhesive. Moreover, increased etching time is not able to modify the bonding strength of the adhesive to irradiated dentin.

Keywords Erbium:yttrium–aluminum–garnet (Er:YAG) · Erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) · Tensile bond strength · Dentin · Laser
The effect of an ErCr:YSGG laser on the micro-shear bond strength of composite to the enamel and dentin of human permanent teeth

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Farnaz Younessian ı Katayoun AM Kalhori ı
Norbert Gutknecht

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Abstract The bond strength of resin composite to Er,Cr: YSGG laser-irradiated enamel and dentin has been evaluated in only a few studies. Therefore, we measured and compared the micro-shear bond strength of composite restorations to enamel and dentin using two different cavity-preparation tools and conditioning methods. One hundred and seventy-five caries-free human third molars were sectioned longitudinally into two different thicknesses and randomly assigned to seven subgroups (n = 25). Enamel groups included laser-cut without etching (LO), laser-cut and acid-etched (LL), laser-cut and acid-etched (LA), bur-cut and laser-etched (BL1), and bur-cut and acid-etched (BA1-comparison group). Dentinal groups included bur-cut and laser-etched (BL2) and bur-cut and acid-etched (BA2-comparison group). The specimens were bonded by Single Bond and Tygon tubes and were restored with Z100 composite. Failure patterns were evaluated using a stereomicroscope, and a shear bond test was performed at 0.5 mm/min. The mean shear bond strength values (MPa) for the LO, LL, LA, BL1 and BA1 enamel groups were 23.14, 23.77, 23.51, 19.30, and 28.99, respectively, whereas for the BL and BA dentinal groups, these values were 22.44 and 26.15, respectively. In enamel specimens, BA1 and LL groups presented the highest shear bond strength values, and the bur-cut and laser-etched (BL1) group showed the lowest values. In the laser-etched groups, bond strength values for bur-cut surfaces were significantly higher than those for laser-cut surfaces. Moreover, there was a significant difference between the BL2 and BA2 dentinal groups. The results of this study indicate that re-etching with acid phosphoric would be recommended if an ErCr:YSGG laser is used for tooth preparation or surface treatment.

Keywords Er,Cr:YSGG · Shear bond strength · Composite
Hard tissue ablation with a spray-assisted mid-IR laser

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Abstract
The objective of this study was to understand the dominant mechanism(s) for
dental enamel ablation with the application of water spray. A free-running
Er,Cr:YSGG (yttrium, scandium, gallium, garnet) laser was used to ablate
human enamel tissue at various radiant exposures. During dental ablation,
distilled water was sprayed on the sample surface, and these results were
compared to ablation without a spray (dry ablation). In order to identify
dominant ablation mechanisms, transient acoustic waves were compared to
ablation thresholds and the volume of material removed. The ablation profile
and depth were measured using optical coherence tomography (OCT). Irregular
surface modification, charring and peripheral cracks were associated with
dry ablation, whereas craters for spray samples were relatively clean without
thermal damage. In spite of a 60% higher ablation threshold for spray associated
irradiations owing to water absorption, acoustic peak pressures were six times
higher and ablation volume was up to a factor of 2 larger compared to dry
ablation. The enhanced pressure and ablation performance of the spray-assisted
process was the result of rapid water vaporization, material ejection with recoil
stress, interstitial water explosion and possibly liquid-jet formation. With water
cooling and abrasive/disruptive mechanical effects, the spray ablation can be
a safe and efficient modality for dental treatment.

(Some figures in this article are in colour only in the electronic version)
Full Length Research Paper

The ablation threshold of Er:YAG laser and Er,Cr:YSGG laser in dental dentin

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Accepted 10 March, 2010

This study aims to investigate the threshold dose for the ablation of dentin of human permanent tooth using erbium: yttrium-aluminium-garnet (Er:YAG, wavelength 2.94 1m, pulse duration 100 1s-50 ms) and erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG, wavelength 2.79 1m; pulse duration 140 1s) lasers. A total of 70 dentin samples were subject to the experiment with varying laser energy densities ranging from 0 - 10 J/cm². The treated dentin surfaces were examined through stereomicroscope and scanning electron microscope. The result of the experiment indicated that both Er:YAG and Er,Cr:YSGG lasers are effective in ablating human tooth dentin. The ablation thresholds for both lasers were determined by inspecting the scanning electron microscopy (SEM) micrographs. The ablation threshold value for Er:YAG laser in dental dentin is 2.97–3.56 J/cm², and for Er,Cr:YSGG laser, it is 2.69 - 3.66 J/cm².

Key words: Dentin, Er:YAG laser, Er,Cr:YSGG laser, ablation, ablation threshold.

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Effects of laser and acid etching and air abrasion on mineral content of dentin

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Abstract The aim of this study was to evaluate the mineral content of dentin prepared using an Er,Cr:YSGG laser at four different power settings, acid etching, and air abrasion. The study teeth comprised 35 molars which were randomly divided into seven equal groups. The occlusal third of the crowns were cut with a slow-speed diamond saw. The groups were as follows: group A, control group; group B, dentin etched with 35% buffered phosphoric acid for 30 s; group C, dentin abraded at 60 psi with 50-µm aluminium oxide for 1 s; groups D–G, dentin irradiated with the Er,Cr:YSGG laser at 1.50 W (group D), 2.25 W (group E), 3.00 W (group F), and 3.50 W (group G). The levels of Mg, P, Ca, K and Na in each dentin slab were measured by inductively coupled plasma-atomic emission spectrometry (ICP-AES). Data were analysed by one way analysis of variance and Tukey HSD tests. There were no significant differences between the groups in the levels of Ca, P and Na, and the Ca/P ratio (p>0.05); however, there were significant differences in the levels of K (p<0.001) and Mg (p=0.13). In addition, the levels of Mg in the air abrasion group were higher than in the other groups (p<0.01). Etching with the Er,Cr:YSGG laser system, air abrasion and acid etching did not affect the levels of Ca, P and Na, or the Ca/P ratio, in the dentin surface.

Keywords Er,Cr:YSGG laser · Air abrasion · ICP-AES · Mineral content

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Abstract The study investigated the influence of varying amounts of air/water spray and the energy used by an erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr: YSGG) 2,780 nm laser when treating dental tissues. The morphological effects produced by the laser interaction on healthy human enamel were evaluated by scanning electron microscopy (SEM). The vestibular and lingual surfaces of ten molars were treated with laser at different power settings; each surface was subdivided into cervical, median, and occlusal parts and treated with different proportions of water spray; the series contained 60 tooth portions. Treatment differed in terms of power setting and air/water percentage. All specimens were then subjected to dehydration and metallisation. At SEM evaluation, the classic aspect of laser-treated enamel was visible: grooves, flakes, shelves and sharp edges, indicative of micro-explosion rather than melting. Vaporisation of the tissue created a clear delimitation from surrounding healthy tissue, with partial respect to the prismatic structure of the treated enamel. The aspect of the enamel was rarely type 1 Silverstone but more frequently type 2 or 3, with prismatic structure not respected and/or completely disordered. These morphological differences appeared to be correlated with the inclination of the laser beam aimed at the enamel prisms and with the percentage of air/water used. The laser system analysed showed itself to be effective at removing human dental enamel. The results appeared to be closely correlated with the variation of the percentage of the laser's water–air spray.

Keywords Erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser · Water spray · Enamel · Scanning electron microscopy (SEM) · Surface morphology

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Part No. 5201385
Evaluation of mineral content of enamel prepared by erbium, chromium:yttrium–scandium–gallium–garnet laser

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Abstract The aim of this study was to evaluate the mineral content of enamel etched at two different power settings with an erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser. Buccal, lingual and mesial or distal surfaces of five premolar teeth were cut, and three enamel slabs were obtained from each tooth. Fifteen enamel specimens were divided into three groups (1 W, 2 W and control) of five specimens each and subjected to Er,Cr:YSGG laser. The mean percentage weights of the five elements [calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and phosphorus (P)] in each slab were measured by inductively coupled plasma-atomic emission spectrometry (ICP-AES). One way analysis of variance (ANOVA) was used to analyze differences among the groups (1 W, 2 W and control). There were no significant differences among the groups (1 W, 2 W and control) for Ca, K, Mg, Na, or P, or for the Ca/P ratio (P>0.05).

Scanning electron microscopy (SEM) photographs indicated that the surface irregularities increased with increased power setting. Laser treatment did not affect the mean percentage weights of Ca, K, Mg, Na, and P, or the Ca/P ratio, in any group.

Keywords Calcium/phosphorus ratio · Elemental composition · Enamel · Erbium, chromium:yttrium–scandium–gallium–garnet laser · Inductively coupled plasma-atomic emission spectrometry (ICP-AES) · Laser treatment

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Part No. 5201385
Composite resin bond strength to primary dentin prepared with ER, CR:YSSG laser

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This in vitro study evaluated the shear bond strength of a hybrid composite resin bonded to primary dentin prepared with an Er,Cr:YSGG hydrokinetic laser compared to conventional bur prepared primary dentin. The results suggest that primary dentin surfaces treated with the Er,Cr:YSGG laser, with or without etching, may provide comparable or increased composite resin bond strengths depending upon bonding agent used.


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Influence of different power outputs of erbium, chromium: yttrium–scandium–gallium–garnet laser and acid etching on shear bond strengths of a dual-cure resin cement to enamel

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Abstract The purpose of the study was to determine if the irradiation of enamel with laser of different output powers might be viable alternatives to acid etching for the bonding of resin luting agents. Seventy-seven maxillary central incisors, extracted for periodontal reasons, were used. The enamel was etched with an erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser operated at one of six power outputs (0.5 W, 0.75 W, 1 W, 1.5 W, 1.75 W and 2 W) or with 38% phosphoric acid. Seventy teeth were used for the bond strength experiments, and the remaining seven (one specimen for each group) were used for scanning electron microscopy (SEM) to determine the topography and morphology of the treated enamel surface. The acid-etched group yielded the highest mean of shear bond strength (13.5 ± 2.8 MPa). The means of the shear bond strength for the teeth irradiated at 0.5 W, 0.75 W, 1 W, 1.5 W, 1.75 W and 2 W laser were 3.28±2.4 MPa, 5.44±3.4 MPa, 8.8±4.5 MPa, 10.2±4.0 MPa, 11.4±4.8 MPa and 11.9±4.3 MPa, respectively. Laser irradiation at 1.5 W, 1.75 W and 2 W produced a type III acid-etched pattern similar to that produced by acid etching. No significant enamel surface etching was obtained by 0.5 W or 0.75 W laser irradiation. Irradiation at 0.5 W and 0.75 W produced a type V acid-etched pattern. We concluded that the mean shear bond strength and enamel surface etching obtained with Er,Cr:YSGG laser (operated at 1.5 W and 1.75 W for 15 s) is comparable to that obtained with acid etching.

Keywords Erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser system · Laser irradiation · Scanning electron microscopy (SEM) examination · Shear bond strength

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Springer
Shear bond strength of bonding to enamel with different laser irradiation distances

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Abstract The aim of this study was to investigate the shear bond strength of bonding to enamel following laser etching with the Er:YAG or Er,Cr:YSGG laser using different irradiation distances. Of 99 extracted human premolar teeth, 90 were divided equally into nine groups. In the control group (group A) the teeth were etched with 38% phosphoric acid. In the laser groups (groups B–I) the enamel surface of the teeth was laser-irradiated, groups B–E with the Er:YAG laser and groups F–I with the Er,Cr:YSGG laser at distances of 1, 2, 4 and 6 mm, respectively. The shear bond strengths were tested using a universal testing machine. The shear bond strengths associated with the Er:YAG laser at 4 and 6 mm and the Er,Cr:YSGG laser at 2, 4 and 6 mm were significantly less than the strengths obtained with the other irradiation distances (p<0.001). The Er:YAG laser at 1 mm and the Er,Cr:YSGG laser at 1 mm etched enamel in the same manner (p>0.05). This finding was confirmed by scanning electron microscopy examination. Irradiation distance did influence the strength of adhesion to enamel. The mean shear bond strengths and enamel surface etching obtained with the Er:YAG laser at 1 and 2 mm and the Er,Cr:YSGG laser at 1 mm were comparable to that obtained with acid etching.

Keywords Laser · Er:YAG · Er,Cr:YSGG · Irradiation distance · Shear test

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Part No. 5201385
PERIODONTAL PROCEDURES

FDA CLEARED INDICATIONS
USE OF WATERLASE IPLUS and MD IS INDICATED FOR:

- Full, partial, and split thickness flap
- Laser soft tissue curettage
- Laser removal of diseased, infected, inflamed and necrosed soft tissue within the periodontal pocket
- Removal of highly inflamed edematous tissue affected by bacteria penetration of the pocket lining and junctional epithelium
- Removal of granulation tissue from bony defects
- Sulcular debridement (removal of diseased, infected, inflamed or necrosed soft tissue in the periodontal pocket to improve clinical indices including gingival index, gingival bleeding index, probe depth, attachment loss and tooth mobility)
- Osteoplasty and osseous recontouring (removal of bone to correct osseous defects and create physiologic osseous contours)
- Ostectomy (resection of bone to restore bony architecture, resection of bone for grafting, etc.)
- Osseous crown lengthening
- Waterlase Er,Cr:YSGG assisted new attachment procedure (cementum-mediated periodontal ligament new-attachment to the root surface in the absence of long junctional epithelium)
- Removal of subgingival calculi in periodontal pockets with periodontitis by closed or open curettage
Comparison of Er, Cr:YSGG Laser and Hand Instrumentation on the Attachment of Periodontal Ligament Fibroblasts to Periodontally Diseased Root Surfaces: An In Vitro Study

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Background: This study investigates the effects of erbium, chromium: yttrium-scandium-gallium-garnet (Er, Cr:YSGG) laser irradiation and hand instrumentation on the attachment of periodontal ligament (PDL) fibroblasts to periodontally involved root surfaces.

Methods: Twenty-four single-rooted periodontally involved human teeth (test groups), and six healthy premolar teeth extracted for orthodontic reasons (control group) were included in this study. A total of 45 root slices were obtained from all selected teeth and assigned to the following five groups: 1) untreated healthy group (+control); 2) untreated periodontally diseased group (-control); 3) hand instrumentation group (scaled Gracey); 4) laser I, Er, Cr:YSGG laser irradiation setting-I (short pulse); and 5) laser II, Er, Cr:YSGG laser irradiation setting-II (long pulse). All of the root slices were autoclaved in phosphate buffered saline and slices were placed onto cell culture inserts. PDL fibroblasts were placed at the density of 80,000 cells on the root plate (5 • 6 mm) and incubated for 48 hours and transferred to 24-well plates. The attachment of PDL fibroblasts on the root plates were observed using confocal microscopy (at 12 hours and on days 3 and 7) and scanning electron microscopy (at 12 hours and day 3). 3-(4,5-dimethyl-thiazol-2-yl)-2,5-diphenyl-tetrazolium bromide assay was performed on day 5 for PDL fibroblast survival.

Results: 3-(4,5-dimethyl-thiazol-2-yl)-2,5-diphenyl-tetrazolium bromide assay shows that whereas laser-treated specimens showed a significantly higher cell density, the Gracey-treated group showed a lower cell density compared to the positive control group (P <0.05). Based on confocal microscopy, apparent reduction was observed in the attachment of PDL cells to the periodontally diseased root surfaces. In the laser and Gracey groups, cells looked well-oriented to the root surfaces. Laser-treated groups provided suitable environment for cell adhesion and growth. Laser I treatment was more favorable for the attachment of PDL compared to scaled Gracey, laser II, and even healthy root surfaces.

Conclusion: The results of the study indicate that short-pulse laser setup (laser I) looks more promising regarding the attachment, spreading, and orientation of PDL cells. J Periodontol 2010;81:1216-1225.

KEY WORDS
Cell biology; fibroblasts; lasers.

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One-year clinical results of Er,Cr:YSGG laser application in addition to scaling and root planing in patients with early to moderate periodontitis

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Abstract  In 30 patients with periodontitis, a total of 278 teeth exhibiting bleeding on probing, subgingival calculus, and a probing depth between 3–6 mm were examined. For each participant, two treatment types were alternatively applied on the contralateral quadrants: scaling and root planing (SRP) as control, and SRP followed by Er,Cr:YSGG laser application (SRP+laser), as a test method. Five clinical parameters: plaque level, bleeding on probing, probing depth, gingival recession and clinical attachment level were examined at baseline and at 2, 3, 6, 12 months after treatment. Of the total of 1,668 sites examined in all patients, 1,088 sites were found with a probing depth of 3–6 mm. In these sites, differences in clinical parameters between SRP and SRP+laser-treated quadrants were analyzed, assuming the level of p<0.05 as significant. After 2 months from baseline, the mean probing depth reduction and the clinical attachment level gain were significantly greater in SRP+laser than in SRP quadrants, and remained so throughout the study (p<0.001). A marked reduction of the bleeding scores occurred in all examined sites, irrespective of the treatment method. However, after 12 months, significantly less teeth exhibited bleeding on probing in SRP+laser quadrants than in SRP quadrants (p<0.001). The mean plaque and gingival recession levels did not differ between the SRP and SRP+laser quadrants neither before nor after the treatment. The periodontal procedures either using Er,Cr:YSGG laser after SRP or SRP alone, lead to significant improvements in all clinical parameters investigated. However, laser application, as an adjunct to SRP, appeared to be more advantageous.

Keywords Er,Cr:YSGG laser · Scaling and root planing · Clinical attachment level

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Part No. 5201385
A pilot study of Er,Cr:YSGG laser therapy used as an adjunct to scaling and root planing in patients with early and moderate periodontitis

_Solveiga Kelbauskiene, Vita Maciulskiene_

**SUMMARY**

Objectives: The study aim was to compare the results of an Er,Cr:YSGG laser therapy used in adjunct to scaling and root planing (SRP), and of SRP alone, in a small group of patients with early to moderate periodontitis. Materials and methods: ten adult patients with periodontitis were treated according to split-mouth design, using Protocol A (SRP alone) or, Protocol B (Er,Cr:YSGG laser therapy combined with SRP). At baseline, and 3 months after the treatment the following periodontal parameters were evaluated: bleeding on probing (BOP), probing depth (PD), plaque index (PI). Results: no statistically significant difference in plaque levels was noted before and after the treatment between the treated quadrants, however a tendency of a more pronounced decrease in plaque levels was noted in the group of laser-SRP treated teeth. After three months, 60-68% decrease of BOP-positive teeth compared to baseline status was noted in all treated quadrants, without significant difference between the treatment modes. The decrease of mean PD values was measured after three months compared to baseline: on the lingual surfaces in 'SRP' group the mean PD improvement value was 0.94±12, and in the laser-SRP group it was 1.96±11, (p<0.001); on the vestibular surfaces the mean improvement values were 0.99±0.14 and 2.03±0.11, respectively (p<0.001). Conclusions: Non-surgical periodontal therapy using both an Er,Cr:YSGG laser + SRP and SRP alone, lead to significant improvements in all the investigated clinical parameters. The combined treatment using laser as an adjunct to root scaling and planing seemed to be advantageous when compared to SRP alone, due to more efficient attachment level restoration.

**Key words:** laser therapy, periodontal attachment, periodontitis, root planing, scaling.

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Effects of Er,Cr:YSGG Laser Irradiation on the Root Surface: Morphologic Analysis and Efficiency of Calculus Removal

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Background: This in vitro study was performed to determine the appropriate power output setting for an erbium, chromium-doped:yttrium, scandium, gallium, and garnet (Er,Cr:YSGG) laser used in periodontal pocket irradiation by examining the morphologic alterations of the root surfaces and the efficiency of calculus removal.

Methods: Sixty-five non-carious extracted human teeth were used in this study. For morphologic analysis of the root surface, the clean, single roots of 22 teeth were separated into 91 pieces, and these pieces were immersed in acrylic resin. The specimens with root-surface exposure were prepared and divided randomly into three groups: a control group (N = 8), an irradiation without water group (no water [NW] group; N = 39), and an irradiation in water to simulate the conditions in a periodontal pocket group (in water [IW] group; N = 44). The power output settings for laser irradiation were 0.5, 1.0, 1.5, and 2.0 W for each group. The roughness (Ra), depth (Z), and width (X) of the disk specimens were determined after laser irradiation. Eight other single-rooted teeth were examined by scanning electron microscopy (SEM) after laser irradiation under the same conditions. Thirty-five single- or multirooted teeth with heavy subgingival calculus were used to test the efficiency of laser scaling. The efficiency of calculus removal was quantified by measuring the time needed to remove the calculus completely using the laser.

Results: The mean Ra and Z values in the IW group were significantly higher than in the NW group with the same power output. In addition, these values with 0.5- and 1.0-W power output settings were significantly lower than with 1.5- and 2.0-W settings in the NW and IW groups. No obvious morphologic differences could be found between the 0.5- and 1.0-W power output specimens under SEM. Additionally, thermal alterations, i.e., carbonization or melting, were completely absent in the IW group. Regarding the efficiency of calculus removal, the 0.5-W setting (0.11 – 0.036 mm²/second) was significantly inferior to the 1.0-W setting (0.27 – 0.043 mm²/second). However, there was no significant difference between 1.0- and 1.5-W (0.36 – 0.11 mm²/second). The 2.0-W setting (0.63 – 0.272 mm²/second) was much more efficient but resulted in significant morphologic alterations.

Conclusions: Based on these findings, it is appropriate to use a 1.0-W power output setting with an Er,Cr:YSGG laser for root scaling. This may be done without any conspicuous morphologic alterations to the root surface and with acceptably efficient removal of calculus. J Periodontol 2007;78:2156-2164.

KEY WORDS

Calculus; laser; root.

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Advantages and esthetic results of erbium, chromium:yttrium–scandium–gallium–garnet laser application in second-stage implant surgery in patients with insufficient gingival attachment: a report of three cases


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Abstract Traditional implant placement involves two surgical stages. Although the second stage is comparatively less aggressive for the patient, postoperative pain and swelling can be further reduced by the use of laser instead of a scalpel. Correct handling of peri-implant soft tissue is of major importance in obtaining adequate gingival tissue attachment around implants. The presence of this keratinized gingiva ensures adequate esthetic results and maintains implant health. We report on three patients with implants in the anterior area who were operated on under the above conditions. Traditionally, the tissue overlying the implants is removed and eliminated. In seeking a way to preserve the attached gingiva, we raised a trapezoidal flap, uncovering each implant and allowing apical repositioning and transpositioning of keratinized gingiva to the buccal side. The results obtained were compared with those from other patients operated on by conventional scalpels. The erbium, chromium:yttrium–scandium–gallium–garnet (Er, Cr:YSGG) laser minimized postoperative pain, and the time to prosthetic rehabilitation was also shortened. The esthetic results were far superior, and no complications were recorded.

Keywords Erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser. Second-stage implant surgery
ENDODONTIC PROCEDURES

FDA CLEARED INDICATIONS

USE OF WATERLASE IPLUS and MD IS INDICATED FOR:

ROOT CANAL HARD TISSUE INDICATIONS

- Tooth preparation to obtain access to root canal
- Root canal preparation including enlargement
- Root canal debridement and cleaning

ENDODONTIC SURGERY INDICATIONS

- Flap preparation – incision of soft tissue to prepare a flap and expose the bone
- Cutting bone to prepare a window access to the apex (apices) of the root(s)
- Apicoectomy – amputation of the root end
- Root end preparation for retrofill amalgam or composite
- Removal of pathological tissues (i.e., cysts, neoplasm or abscess) and hyperplastic tissues (i.e., granulation tissue) from around the apex

ROOT CANAL DISINFECTION

- Laser root canal disinfection after endodontic instrumentation
Laser Activation of Endodontic Irrigants with Improved Conical Laser Fiber Tips for Removing Smear Layer in the Apical Third of the Root Canal

ROY GEORGE, BDS, MDS, IAN A. MEYERS, BDSC, AND LAURENCE J. WALSH, PHD, DDSC

Abstract

With a tube etching process, conical-ended optical fibers for middle infrared lasers that have lateral emissions can be produced, a feature of benefit for delivering laser energy onto the root canal walls. This study examined the ability of these improved laser tips when Er:YAG and Er,Cr:YSGG lasers were used in root canals in which thick smear layers had been created intentionally to provide a challenge for the laser system. Smear layer was assessed from scanning electron microscopy images with an objective digital method. Lasing improved the action of ethylene diamine tetraacetic acid with cetavlon (EDTAC) in removing smear layer. Conical fibers performed better than plain fibers, but there was no difference in performance between the 2 laser systems when matched for all other parameters. These results provide a "proof of concept" for lateral emitting fibers for endodontic procedures and illustrate the novel contribution of lasing to the action of EDTAC in dissolving smear layer. (J Endod 2008;34:1524–1527)

Key Words
Dentin ablation, erbium lasers, laser dentistry, smear layer

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Thermal Effects from Modified Endodontic Laser Tips Used in the Apical Third of Root Canals with Erbium-Doped Yttrium Aluminium Garnet and Erbium, Chromium–Doped Yttrium Scandium Gallium Garnet Lasers

Roy George, M.D.Sc., Ph.D., and Laurence J. Walsh, B.D.Sc., Ph.D.

Abstract

Objective: To evaluate the temperature changes occurring on the apical third of root surfaces when erbium-doped yttrium aluminium garnet (Er:YAG) and erbium, chromium–doped yttrium scandium gallium garnet (Er,Cr:YSGG) laser energy was delivered with a tube etched, laterally emitting conical tip and a conventional bare design optical fiber tip. Background Data: Thermal effects of root canal laser treatments on periodontal ligament cells and alveolar bone are of concern in terms of safety. Materials and Methods: A total of 64 single-rooted extracted teeth were prepared 1 mm short of the working length using rotary nickel–titanium Pro-Taper files to an apical size corresponding to a F5 Pro-Taper instrument. A thermocouple located 2 mm from the apex was used to record temperature changes arising from delivery of laser energy through laterally emitting conical tips or plain tips, using an Er:YAG or Er,Cr:YSGG laser. Results: For the Er:YAG and Er,Cr:YSGG systems, conical fibers showed greater lateral emissions (452°C 69% and 443°C 64%) and corresponding lower forward emissions (48°C 5% and 49°C 5%) than conventional plain-fiber tips. All four combinations of laser system and fiber design elicited temperature increases less than 2.58°C during lasing. The use of water irrigation attenuated completely the thermal effects of individual lasing cycles. Conclusions: Laterally emitting conical fiber tips can be used safely under defined conditions for intracanal irradiation without harmful thermal effects on the periodontal apparatus.

School of Dentistry, University of Queensland, Brisbane, Australia.
The antimicrobial efficacy of the erbium, chromium:yttrium-scandium-gallium-garnet laser with radial emitting tips on root canal dentin walls infected with Enterococcus faecalis

Wanda Gordon, DMD; Vahid A. Atabakhsh, DDS; Fernando Meza, DMD; Aaron Doms, DDS; Roni Nissan, DMD; Ioana Rizoiu, MS; Roy H. Stevens, DDS, MS

ABSTRACT

Background. The authors used an in vitro model to investigate the ability of an erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser with radial emitting tips to disinfect Enterococcus faecalis–infected dentin.

Materials and Methods. The in vitro infected-dentin model system consisted of a dentin cylinder, prepared from a human anterior tooth root, cemented into a sealable two-chamber device fabricated from a syringe needle cap. The model’s lower chamber contained a buffer solution, and the dentin cylinder was placed between the upper and lower chambers. After sterilization, the authors inoculated the root canal of each dentin cylinder with E. faecalis. They used an Er,Cr:YSGG laser with radial emitting tips to irradiate the root canal of each infected dentin cylinder (varying laser power and exposure time). After laser treatment, the authors machined the root canal dentin walls and collected the resulting dentin filings in the buffer-reservoir. They quantified the E. faecalis titer of each buffer-reservoir by using selective agar plates.

Results. The authors found that bacterial recovery decreased when laser irradiation duration or power increased. A greater degree of disinfection was achieved with a 120-second application of laser than with sodium hypochlorite treatment. Finally, they found that a 99.7 percent reduction in bacterial counts could be obtained using the laser.

Conclusion. The results of this study suggest that the Er,Cr:YSGG laser with a radial emitting tip has a significant antimicrobial effect on dentinal tubules infected with E. faecalis.

Clinical Implications. Er,Cr:YSGG laser treatment could be a valuable tool for root canal disinfection during endodontic treatment.

Keywords. Bacteria; disinfection; endodontic therapy; lasers; root canal.

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K. M. Rownak Jahan · Mozammal Hossain · Yukio Nakamura · Yamada Yoshishige · Jun-Ichiro Kinoshita · Koukichi Matsumoto

An assessment following root canal preparation by Er,Cr: YSGG laser irradiation in straight and curved roots, in vitro

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Abstract In the present study, the effectiveness of Er,Cr: YSGG laser in straight and curved root canal preparation was compared with that of the conventional canal preparation technique, in vitro. The degree of root curvature of 40 root canals was determined, and then 20 canals were prepared by an Er,Cr:YSGG laser of 2 W by using the crown-down technique, while the other 20 canals were shaped by K-file (control). The achievement degree of root canal preparation and debris score was investigated morphologically. The results indicated that straight root canals could be successfully prepared by Er,Cr:YSGG laser irradiation; a significant decrease of smear layer or debris was also recognized (P<0.01). However, canal preparation by laser device in curve root often leads to a ledge or zipped formation, perforation or over-instrumentation. The results demonstrated that further development in laser device and technique are required to ensure its success in root canal preparation, especially in curve root.

Keywords Er · Cr:YSGG laser · Straight and curved root canal preparation · Crown-down technique · Debris removal

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Part No. 5201385
In vitro preliminary study to evaluate the capability of Er, Cr:YSGG laser in posterior teeth root-canal preparation with step-back technique

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Abstract This preliminary study was to investigate in vitro the Er,Cr:YSGG laser ablation capability, both range (enlargement aspects of laser tips corresponded to conventional endodontic files) and quality (removing of smear layer and opening of dentinal tubules) to clean and shape the root canal for final obturation step. The crowns of 15 extracted multi-rooted posterior human teeth were resected, and then 15 canals were prepared by an Er,Cr:YSGG laser up to 1.5 W (actual power output) using the step-back technique, while the other 15 canals (control) were enlarged conventionally by K-flex file. The results revealed that posterior root-canal preparation could be achieved by laser beam transmitted to the canal using endodontic tips. At a chosen significance level of α = 1%, the results showed no significant statistical difference between the two groups (P > 0.01). Considering the results of this current study, laser-based root-canal preparation still shows certain limitations, and further improvements are mandatory for higher achievement and better preparation outcomes.

Keywords Laser root-canal preparation · Er,Cr:YSGG laser · Step-back technique

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Part No. 5201385
A comparison of the efficacy of Er,Cr:YSGG laser and rotary instrumentation in root canal débridement

Daniel A. Radatti, DDS; J. Craig Baumgartner, DDS, PhD; J. Gordon Marshall, DMD

ABSTRACT

Background. The authors evaluated the efficacy of an erbium, chromium: yttrium scandium gallium garnet (Er,Cr:YSGG) laser-powered hydrokinetic system (HKS) versus that of rotary instrumentation for root canal débridement.

Methods. The authors studied four uninstrumented controls and two test groups of 18 matched pairs of teeth. Teeth from each pair underwent different instrumentation but received identical irrigation solutions. The instrumentation protocol involved either rotary instrumentation or the Er,Cr:YSGG laser. The irrigation groups received 0.5 milliliter of distilled water or 5.25 percent sodium hypochlorite (NaOCl) between instruments. The authors measured the amount of debris remaining at 2 and 4 mm from the apex as a percentage of total lumen area.

Results. Lased canals had significantly more debris than did canals that received rotary instrumentation (Wilcoxon signed rank test, \( P < .001 \)). With distilled water irrigation, the debris remaining in lased canals at both the 2- and 4-mm levels was not statistically different from that remaining in uninstrumented controls. Rotary instrumentation yielded significantly less remaining debris than did laser instrumentation (Wilcoxon signed rank test, \( P < .001 \)). With 5.25 percent NaOCl irrigation, there was no difference in remaining debris between the two groups (Wilcoxon signed rank test, \( P < .001 \)). The lased group received significantly more irrigant than did the rotary group (Wilcoxon rank sum test, \( P < .001 \)).

Conclusions. This study indicates that the débridement efficacy of the HKS with distilled water irrigation is unacceptable; with 5.25 percent NaOCl irrigation, it is similar to that of rotary instrumentation.

Clinical Implications. If the HKS is to be used for débridement, then NaOCl irrigation must be used for predictable tissue removal.

Key Words. Er,Cr:YSGG; laser; hydrokinetic system; endodontic treatment; root canal; débridement.

JADA 2006;137(9):1261-6.
Comparison of the effect of Er, Cr-YSGG laser and ultrasonic retrograde root-end cavity preparation on the integrity of root apices

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(Received 20 August and accepted 22 December 2009)

Abstract: The aim of this study was to compare the effect of Waterlase laser and ultrasonic root end cavity preparation on the integrity of root end in extracted human teeth. The canals of 60 extracted maxillary central incisors were cleaned, shaped, obturated and 3 mm of the root end was resected and examined for the presence of any cracks. Class I root-end cavities were then prepared using an ultrasonic unit or Waterlase laser. In the ultrasonic group, K1S2D tip and medium intensity and in the laser group, 600 μm laser tips and an output power setting of 4 W with 55% water and 65% air were used to prepare the cavity which was studied for the presence of any cracks or chippings. One crack was found in the ultrasonic group, while no cracks were observed in the laser group. There was no significant difference between the two groups (P > 0.05). As for the chipping effect, seven cases (23%) had chipping after cavity preparation in the ultrasonic group but no chipping was found in the specimens of the laser group and the difference was statistically significant (P < 0.05). According to the results of this in vitro study, laser preserves the integrity of root-end cavities better than ultrasonic devices from the standpoint of producing chipping. (J Oral Sci 52, 77-81, 2010)

Keywords: crack; chipping; Er, Cr-YSGG laser; root-end preparation; ultrasonic.

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Introduction

The use of ultrasonic tips has become widely accepted for root-end cavity preparation as they have a number of advantages including their smaller dimensions and improved access to the resected root-end cavities (1).

Saunders et al. (2) were the first to report more crack propagation in resected root-end surface with ultrasonic root-end preparation than a round bur on a slow-speed handpiece. Furthermore, Abedi et al. (3) studied the effect of root-end cavity preparation with bur and ultrasonic and concluded that significantly fewer cracks were observed with bur compared to ultrasonic. Waplington et al. (4) found no significant difference in cracking between high power ultrasonic and bur; however, the chipping was more associated with the ultrasonic device.

Studies have demonstrated that using a higher power setting of the ultrasonic device for root-end cavity preparation creates more cracks compared with medium and low powers (5,6). In another study, De Bruyne et al. (7) investigated the root-end integrity after preparing root-end cavities with medium and low power settings of the ultrasonic unit and observed no significant difference in the cracks produced between medium and low powers.

Waterlase laser (Biolase® Technology Inc, San Clement, CA, USA), an Er, Cr:YSGG laser (Erbium, Chromium: Yttrium, Scandium, Gallium and Garnet) has been presented as an effective means to resect root ends, prepare root-end cavity, staunch blood, and sterilize root apex and surrounding tissues in endodontic surgery (8). The
The impact of an erbium, chromium: yttrium-scandium-gallium-garnet laser with radial-firing tips on endodontic treatment

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Abstract  Radial-firing tips should allow a more homogeneous laser irradiation of root canal walls. The aim of the study was to assess the effects of erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser irradiation in conjunction with those newly designed tips. The investigation comprised bacteriology, morphological evaluations and temperature measurements. Root canals were inoculated with two test strains and laser irradiated with power settings of 0.6 W and 0.9 W and a repetition rate of 20 Hz. Subsequently, the samples were subjected to microbiological evaluation. The morphological changes of the canal walls were assessed by scanning electron microscopy. To reveal possible thermal side effects, we carried out temperature measurements. The bacteriological evaluation revealed a decisive disinfectant effect. Scanning electron microscopy showed the homogeneous removal of smear layer from the root canal walls. The temperature rise at the root surface during the irradiation was moderate, yielding 1.3°C for the 0.6 W setting and 1.6°C for the 0.9 W setting. The investigations indicated that the Er,Cr: YSGG laser, in conjunction with radial-firing tips, is a suitable tool for the elimination of bacteria in root canals and for the removal of smear layer.

Keywords  Endodontics · Root canal · Laser · Radial-firing tips · Bacteriology · Scanning electron microscopy
The use of the erbium, chromium:yttrium-scandium-gallium-garnet laser in endodontic treatment
The results of an in vitro study

Ulrich Schoop, DDS, MD; Kawe Goharkhay, DMD, MD; Johannes Klimescha, DMD, MD; Manuela Zagler, DMD; Johann Wernisch, TD, PhD; Apostolos Georgopoulos, MD, PhD; Wolfgang Sperr, DDS, MD, PhD; Andreas Moritz, DMD, MD, PhD

ABSTRACT

Background. The use of the erbium, chromium:yttrium-scandium-gallium-garnet (Er:Cr:YSGG) laser has become accepted in the field of cavity preparation. The development of miniaturized and flexible fiber tips has allowed this device to be used in endodontics. The authors conducted an in vitro study to assess the effects of Er:Cr:YSGG laser irradiation on root canals.

Methods. The authors inoculated root canals with two bacteria, laser irradiated them at two power settings and subjected them to a quantitative microbiological evaluation. They used scanning electron microscopy (SEM) to assess morphological changes in endodontically processed and laser-irradiated root canal walls. They measured temperature increases on the root surface to determine possible thermal side effects.

Results. The bacteriological evaluation revealed a disinfecting effect in the root dentin samples that was dependent on the output power but not specific for the bacterial species investigated. SEM showed the removal of the smear layer from the root canal walls and the exposure of dentinal tubules. The temperature rise during irradiation was moderate when standardized power settings were used.

Conclusions. The Er:Cr:YSGG laser can be used to eliminate bacteria in root canals. It also effectively removes smear layer and debris from the canal wall.

Clinical Implications. Practitioners can use the Er:Cr:YSGG laser to prepare root canals for endodontic therapy.

Key Words. Endodontics; root canal; laser; bacteriology; scanning electron microscopy.

Impact of Er, Cr:YSGG Laser Therapy on the Cleanliness of the Root Canal Walls of Primary Teeth

Flavio Soares, DDS, MS,* Claudio H. Varella, DDS, MS,† Roberta Pileggi, DDS, MS,* Abi Adewumi, BDS, FDSRCS, MPaed Dent RCS,* and Marcio Guelmann, DDS*

Abstract
Root canal therapy might be required for primary teeth displaying signs of pulpal inflammation or necrosis. Cleaning and shaping followed by obturation of the canal space with a resorbable paste have been widely performed with remarkable clinical success. However, lengthy endodontic procedures might be contraindicated when treating certain pediatric patients. The aim of this study was to compare the cleanliness of the root canal walls of primary teeth and the time required for the completion of the cleaning and shaping procedures performed by the Er, Cr:YSGG laser, manual or rotary instrumentation techniques. Thirty-five extracted, single-rooted, primary teeth were divided into 4 groups: I, canals were instrumented with Profile .04 rotary instruments to a master apical file size #35; II, the laser was used (parameters: 1.50 W, 20 pps, 30% water and 50% air) with a Z3 laser tip (0.32-mm diameter); III, canals were instrumented with stainless steel K-files; and IV, no instrumentation was performed (control). The teeth were split in 2 halves and prepared for scanning electron microscopy analysis. Images from the coronal, middle, and apical thirds of the roots were analyzed independently by 2 calibrated, blinded evaluators. Statistical analysis revealed significant differences among the groups (Kruskal-Wallis, P = .0001). The techniques were not capable of providing completely clean canals. Treatment with Er, Cr:YSGG laser provided similar cleanliness when compared with rotary instrumentation technique and was superior to manual instrumentation. The laser technique required less time for completion of the cleaning and shaping procedures when compared with both rotary or hand instrumentation. (J Endod 2008;34:474–477)

Key Words
Cleaning and shaping, lasers, primary teeth, root canal therapy
Evaluation of the Bactericidal Effect of Er,Cr:YSGG, and Nd:YAG Lasers in Experimentally Infected Root Canals

Qian-qian Wang, DDS, Cheng-fei Zhang, DDS, PhD, and Xing-zhe Yin, DDS

Abstract
The aim of this study was to evaluate the bactericidal effect of the Er,Cr:YSGG laser and the Nd:YAG laser in experimentally infected root canals. Sixty single-rooted teeth with straight canals were selected. After preparation and sterilization, the specimens were inoculated with Enterococcus faecalis for 3 weeks. After irradiation by lasers, the number of bacteria in each root canal was examined. The Er,Cr:YSGG laser gave a reduction of 77% after irradiation at 1 W and 96% at 1.5 W, but there was no significant difference (p > 0.05). The Nd:YAG laser gave a reduction of 97% at 1 W and 98% at 1.5 W, and there was no significant difference (p > 0.05). Compared with the Er,Cr:YSGG laser, the Nd:YAG laser is more effective (p < 0.05). In conclusion, both laser systems have a significant bactericidal effect in infected root canals, and the Nd:YAG laser is more effective than the Er,Cr:YSGG laser. (J Endod 2007;33:830 –832)

Key Words
Bactericidal, Er,Cr:YSGG laser, Nd:YAG laser, root canal
**In vitro** evaluation of the temperature increment at the external root surface after Er,Cr:YSGG laser irradiation of the root canal

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Abstract
Objectives. A study was made to determine the temperature increment at the dental root surface following Er,Cr:YSGG laser irradiation of the root canal.

Design. Human canines and incisors previously instrumented to K file number ISO 30 were used. Irradiation was carried out with glass fiber endodontic tips measuring 200 l/min in diameter and especially designed for insertion in the root canal. The teeth were irradiated at 1 and 2 W for 30 seconds, without water spraying or air, and applying a continuous circular movement (approximately 2 mm/sec) in the apico-coronal direction.

Results. At the 1 W power setting, the mean temperature increment was 3.84°C versus 5.01°C at 2 W. In all cases the difference in mean value obtained after irradiation versus the mean baseline temperature proved statistically significant (p < 0.05).

Conclusions. Application of the Er,Cr:YSGG laser gives rise to a statistically significant temperature increment at the external root surface, though this increment is probably clinically irrelevant, since it would appear to damage the tissues (periodental ligament and alveolar bone) in proximity to the treated tooth.

**Key words:** Er, Cr:YSGG, endodontics, temperature, root canal, laser.
Bactericidal activity of erbium, chromium: yttrium–scandium–gallium–garnet laser in root canals

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Abstract  The aim of this study was to investigate the effectiveness of the erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser by measuring its bactericidal effect inside root canals experimentally colonized with Enterococcus faecalis. We also determined the optimal conditions for the Er,Cr:YSGG laser to achieve the maximal bactericidal effect. An Er,Cr:YSGG Waterlase™ laser was used, and its antimicrobial effect was compared with that of sodium hypochlorite (NaOCl) at various concentrations as widely used in clinics. This laser emits photons at a wavelength of 2.78 μm. It is a pulsed laser operating at 20 Hz (20 pulses/s). Significant differences between measurements in the different groups (P < 0.05) were observed, depending on time and power used. The use of NaOCl 5% was the most effective procedure, with NaOCl 0.5% being the least effective; however, laser treatment was as effective as NaOCl 5% when applied at 2 W for 60 s.

Keywords Laser · Endodontics · Disinfection · Enterococcus

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Part No. 5201385
Comparison of Bacterial Reduction in Straight and Curved Canals Using Erbium, Chromium:Yttrium-Scandium-Gallium-Garnet Laser Treatment versus a Traditional Irrigation Technique With Sodium Hypochlorite

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Abstract
Introduction: This study compared the reduction of Enterococcus faecalis in straight and curved canals using an erbium, chromium:yttrium-scandium-gallium-garnet laser and irrigation with 6.15% sodium hypochlorite (NaOCl). Methods: Fifty-five single-rooted extracted teeth were divided into straight and curved canal groups. The root lengths were standardized (14.0 mm) and NiTi instruments were used to prepare the canals to a size #40/0.06 taper. Irrigation was performed with 6.15% NaOCl and RCPrep (Premier Dental Products Co, Plymouth Meeting, PA) as lubricant. The smear layer was removed with 17% EDTA. The samples were sterilized, inoculated with E. faecalis, and incubated for 48 hours at 37°C in a CO2 chamber. They were then divided into 7 groups: NaOCl in straight canals (NS); NaOCl in curved canals (NC); laser in straight canals (LS); laser in curved canals (LC); positive control straight canals (PCS); positive control curved canals (PCC); and negative control (NegC). Bacterial reduction was measured by counting the colony-forming units (CFUs) and determining the optical density. Results: Groups NS, NC, and LS exhibited bacterial growth in 1 out of 10 samples (10%). In group LC, three out of 10 samples (30%) showed bacterial growth. Kruskal-Wallis showed a statistically significant difference between all treatment groups and the positive controls (p < 0.001). Analysis of variance showed a statistical significant difference in optical density between experimental and positive controls. Conclusions: Traditional irrigation techniques using 6.15% NaOCl effectively eliminated all bacteria in straight and curved canals. Er:Cr:YSGG laser also effectively removed all bacteria from straight canals. However, in three curved canals, even though there were significant bacterial reductions, they failed to render canals completely free of bacteria. (J Endod 2010;36:725–728)

Key Words
Er:Cr:YSGG laser, lasers, root canal disinfection, root canal irrigation, sodium hypochlorite

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Bacterial Reduction Using Er:Cr:YSGG Laser Treatment versus Irrigation with NaOCl

Part No. 5201385
SOFT TISSUE PROCEDURES

FDA CLEARED INDICATIONS

USE OF WATERLASE IPLUS and MD IS INDICATED FOR:

- Excisional and incisional biopsies
- Exposure of unerupted teeth
- Fibroma removal
- Flap preparation – incision of soft tissue to prepare a flap and expose the bone or unerupted teeth (hard and soft tissue impactions).
- Frenectomy and frenotomy
- Gingival troughing for crown impressions
- Gingivectomy
- Gingivoplasty
- Gingival incision and excision
- Hemostasis
- Implant recovery
- Incision and drainage of abscesses
- Laser soft tissue curettage of the post-extraction tooth sockets and the periapical area during apical surgery
- Leukoplakia
- Operculectomy
- Oral papillectomies
- Pulpotomy
- Pulp extirpation
- Pulpotomy as an adjunct to root canal therapy
- Root canal debridement and cleaning
- Reduction of gingival hypertrophy
- Removal of pathological tissues (i.e., cysts, neoplasm or abscess) and hyperplastic tissues (i.e., granulation tissue) from around the apex
- Soft tissue crown lengthening
- Treatment of canker sores, herpetic and aphthous ulcers of the oral mucosa
- Vestibuloplasty * For use on adult and pediatric patients
Comparative study of upper lip frenectomy with the CO$_2$ laser versus the Er, Cr:YSGG laser

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Abstract
Objectives: To compare upper lip frenulum reinsertion, bleeding, surgical time and surgical wound healing in frenectomies performed with the CO$_2$ laser versus the Er, Cr:YSGG laser.
Study design: A prospective study was carried out on 50 randomized pediatric patients who underwent rhomboidal resection of the upper lip frenulum with either the CO$_2$ laser or the Er,Cr:YSGG laser. Twenty-five patients were assigned to each laser system. All patients were examined at 7, 14, 21 days and 4 months after the operation in order to assess the surgical wound healing.
Results: Insertion of the frenulum, which was preoperatively located between the upper central incisors, migrated to the mucogingival junction as a result of using both laser systems in all patients. Only two patients required a single dose of 650 mg of paracetamol, one of either study group. CO$_2$ laser registered improved intraoperative bleeding control results and shorter surgical times. On the other hand, the Er,Cr:YSGG laser achieved faster healing.
Conclusions: Upper lip laser frenectomy is a simple technique that results in minimum or no postoperative swelling or pain, and which involves upper lip frenulum reinsertion at the mucogingival junction. The CO$_2$ laser offers a bloodless field and shorter surgical times compared with the Er,Cr:YSGG laser. On the other hand, the Er,Cr:YSGG laser achieved faster wound healing.

Key words: Frenectomy, upper lip frenulum, CO$_2$ laser, Er,Cr:YSGG laser, laser.

Part No. 5201385
The impact of laser application on periodontal and peri-implant wound healing

Frank Schwarz, Akira Aoki, Anton Sculean & Jürgen Becker

In some patients gingivitis progresses to periodontitis, and this progression is mainly influenced by the individual's immune and inflammatory responses to the formation of microbial biofilm on teeth. Periodontal disease is characterized by the destruction of the supporting structures of the teeth, including the periodontal ligament, bone and soft tissues, which in turn may ultimately cause tooth loss (36). Similarly, the host response to biofilm formation on implant surfaces includes a series of inflammatory reactions that are initially located in the mucosa but may subsequently progress and lead to a loss of supporting alveolar bone (103). The response of the soft tissues surrounding both teeth and implants to short periods and also to more long-standing periods of plaque accumulation has been analyzed in experimental animal studies (8, 22) as well as in human studies (53, 64). It was observed that the quantity and composition of developing bacterial biofilms was comparable on tooth and implant surfaces. Based on these findings, it may be suggested that early microbial colonization of titanium implants follows the same pattern as that on teeth (50). A cause-related therapy of either periodontal or peri-implant infections is aimed at resolving infection and inflammation and thereby arresting disease progression (9, 37). Ideally, therapy not only includes arresting periodontal disease but also regeneration of the tissues that have been lost as a result of the disease. In recent years, the use of laser radiation has been investigated as an alternative or adjunctive tool to conventional, mechanical and antiseptic procedures commonly employed in the treatment of periodontal and peri-implant diseases. Various beneficial characteristics, such as hemostatic effects, selective calculus ablation or bactericidal effects against periodontal pathogens, might lead to improved treatment outcomes (2–4, 27). The objective of the present review was to evaluate preclinical and clinical studies aimed at investigating the pattern of wound healing following treatment of either periodontal or peri-implant infections using laser wavelengths most commonly employed in dentistry.

Laser characteristics

A laser is a device that emits light through a process called stimulated emission (21), featuring collimated (parallel) and coherent (temporally and spatially constant) electromagnetic radiation of a single wavelength. When it reaches biological tissues, the laser light can be reflected, scattered, absorbed, or transmitted to the surrounding tissues (Fig. 1). The emission wavelength mainly influences these modes of interaction in the target tissue and must therefore be selected with caution for any diagnostic or therapeutic interventions.

The wavelengths of the lasers most commonly used for the treatment of periodontal and peri-implant diseases, which include semiconductor diode lasers, solid-state lasers [–neodymium-doped: yttrium, aluminium and garnet (Nd:YAG); neodymium-doped: yttrium, aluminium and perovskite (Nd:YAP); erbium-doped: yttrium, aluminium and garnet (Er:YAG); and erbium, chromium-doped yttrium, scandium, gallium and garnet (Er,Cr:YSGG)] and gas lasers (CO₂), range from 635 to 10,600 nm (4).

According to the cause-related concept of periodontal /peri-implant treatment, thorough removal of any bacterial deposits without causing major damage to the adjacent tissues may be required in order to effect healing at diseased sites.

For these specific therapeutic interventions, the emission wavelength will potentially interact with the following:
The current status of laser applications in dentistry

LJ Walsh*

Abstract
A range of lasers is now available for use in dentistry. This paper summarizes key current and emerging applications for lasers in clinical practice. A major diagnostic application of low power lasers is the detection of caries, using fluorescence elicited from hydroxyapatite or from bacterial by-products. Laser fluorescence is an effective method for detecting and quantifying incipient occlusal and cervical carious lesions, and with further refinement could be used in the same manner for proximal lesions. Photoactivated dye techniques have been developed which use low power lasers to elicit a photochemical reaction. Photoactivated dye techniques can be used to disinfect root canals, periodontal pockets, cavity preparations and sites of peri-implantitis. Using similar principles, more powerful lasers can be used for photodynamic therapy in the treatment of malignancies of the oral mucosa. Laser-driven photochemical reactions can also be used for tooth whitening. In combination with fluoride, laser irradiation can improve the resistance of tooth structure to demineralization, and this application is of particular benefit for susceptible sites in high caries risk patients. Laser technology for caries removal, cavity preparation and soft tissue surgery is at a high state of refinement, having had several decades of development up to the present time. Used in conjunction with or as a replacement for traditional methods, it is expected that specific laser technologies will become an essential component of contemporary dental practice over the next decade.

Key words: Lasers, dental applications, débridement, photosensitization, resin curing.

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Treatment of Gingival Pigmentation with Er,Cr:YSGG Laser

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Purpose: Melanin hyperpigmented gingiva is an esthetic problem in many individuals, particularly if the hyperpigmentation is on the facial aspect of gingiva and visible during smile and speech, especially in patients with gummy smiles. Gingival depigmentation has been carried out using surgical, chemical, electrosurgical, and cryosurgical procedures. The two cases presented here show the successful depigmentation using an Er,Cr:YSGG laser, and a short follow-up period (6 months) for repigmentation results.

Materials and Methods: An Er,Cr:YSGG hydrokinetic system laser set at 20 W, 1.75 W to 1.35 W, wvth 20 to 40% air and 12% to 5% water spray was used for removal of pigmented gingiva in 2 patients. The pigmented areas were treated in noncontact mode, and both cases were completed during one appointment.

Results: Even though both cases were performed without any anesthesia, no intra-operative or postoperative pain or discomfort appeared. After 24 h, the lasered gingiva was pearly white with a thin layer of fibrin, which exfoliated during the first week following treatment. The ablated wound healed almost completely within 1 week.

Conclusion: These results pointed out that YSGG is a good and safe choice for removal of pigmented gumi with local anesthesia. The postoperative period is comfortable for the patient and healing is fast and good. No repigmentation occurred in either patient after 6 months.

Keywords: Er,Cr:YSGG, laser, hyperpigmentation, hydrokinetic system, depigmentation.

Soft-Tissue Management Using an Er, Cr:YSGG Laser During Restorative Procedures

by Cynthia Jetter, DMD

Abstract
Effective management of gingival tissues in restorative dentistry poses a challenge to practitioners. Many methods and materials are available to dental professionals to manage tissue. This article will demonstrate the use of an Er,Cr:YSGG laser as an effective, minimally invasive technology to manage soft tissue during restorative procedures.
BONE TISSUE PROCEDURES

FDA CLEARED INDICATIONS

USE OF WATERLASE IPLUS and MD IS INDICATED FOR:

- Cutting, shaving, contouring and resection of oral osseous tissues (bone)
- Osteotomy
PROCUREMENT OF AUTOGENOUS BONE FROM THE MANDIBULAR RAMUS WITH SIMULTANEOUS THIRD-MOLAR REMOVAL FOR BONE GRAFTING USING THE ER, CR:YSGG LASER: A PRELIMINARY REPORT

Cameron Y. S. Lee, DMD, MD

Key Words
Laser
Osseous surgery
Hydrokinetic effect
Bone grafting
Third-molar removal
Morbidity

Autogenous bone grafting and third-molar removal are surgical procedures routinely performed in dentistry on a daily basis. The purpose of this preliminary report is to describe our clinical experience with the Er, Cr:YSGG laser in the procurement of bone harvested from the ramus and removal of third molars simultaneously from the mandible.

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Erbium, chromium:yttrium–scandium–gallium–garnet laser-assisted sinus graft procedure

Dong-Seok Sohn & Ji-Soo Lee & Kyung-Mi An & George E. Romanos

Abstract The possibility of using lasers in the field of dentistry has been a subject of investigation. There are few reports that any laser systems have been used for bony window osteotomy by direct sinus grafting. In this study, erbium, chromium:yttrium–scandium–gallium–garnet (Er, Cr:YSGG) laser of various laser systems was used for 12 sinus bone grafts in ten patients, and the efficiency of the laser was evaluated according to the osteotomy time and the rate of sinus membrane perforation in the clinical results; the mechanism is described. Eight of the 12 procedures were performed by direct sinus grafting with the Er, Cr:YSGG laser without membrane perforation (perforation ratio 33.3%). Operating time for bony window osteotomy with laser alone was 2–7 minutes [3 min 24 s on average; 3.4±1.4 min (mean ± standard deviation)], and all the implants placed immediately were successful.

Keywords Erbium, chromium:yttrium–scandium–gallium–garnet (Er, Cr:YSGG) laser . Membrane perforation . Sinus bone graft . Window osteotomy

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