The use of the erbium, chromium:yttrium-scandium-gallium-garnet laser in endodontic treatment

The results of an in vitro study

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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.

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One objective in endodontic therapy is to sanitize the root canal and the three-dimensional network of dentinal tubules. Bacteria from infected pulp tissue can penetrate into the deeper layers of root dentin and propagate periapical inflammation with subsequent destruction of the adjacent connective tissues.[1-3]

The local microenvironment of the root canal system favors the selection of a few bacterial species that can survive and proliferate when they are out of reach of the host's immune response.[4-8] Rinsing solutions used during conventional root canal treatment affect those bacteria only partially. The pathogenic microorganisms are able to penetrate the root dentin up to more than 1 millimeter, whereas rinsing solutions reach a depth of around only 100 micrometers.[9,10] In addition, bacteria such as *Enterococcus faecalis* are able to form intra- and extraradicular biofilms, which makes it even harder to con-

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trol them.[11-13] These facts often are the reasons for cases that are resistant to therapy from the beginning or end up as long-term failures after endodontic treatment.

Considering this, disinfecting the root canal—including the most distant areas of the tubular system—is a major challenge in endodontic treatment and is of fundamental importance for the prolonged preservation of endodontically treated teeth. The use of lasers in the field of endodontics is an innovative approach for meeting these requirements. In general, dental lasers provide access to formerly unreachable parts of the tubular network, owing to the fact that they penetrate dental tissues better than rinsing solutions.[14-16]

Since the early 1980s, several studies on the impact of different laser systems on the root canal and the surrounding dentin have been published. The carbon dioxide (CO_2) laser, which emits a wavelength of 10,600 nanometers, has been used in surgery for a long period. In 1986, Zakariasen and colleagues[17] showed for the first time that this wavelength could be used in endodontics with a good bactericidal effect. In 1995, Moritz and colleagues[18] achieved a partial closure of dentinal tubules using the CO_2 laser on root canal surfaces. Owing to the fact that the emitted long wave infrared radiation (10,600 nm) can be transmitted into the root canal exclusively by using a rigid hollow wave guide, the canal lumen must be well-prepared and the laser can be used only in straight root canals.

An in vitro study by Pini and colleagues[19] focused on the use of the xenon chloride (XeCl) excimer laser, which emits ultraviolet radiation at 308 nm. This low wavelength leads to a satisfactory removal of hard tissues and a bactericidal effect with only limited thermal side effects. The requirements of technical resources are tremendous and, therefore, the use of the XeCl excimer laser remains restricted primarily to basic research.

Moshonov and colleagues[20] demonstrated the efficacy of the argon laser in removing intracanal debris by means of computerized scanning electron microscopy (SEM), whereas Blankenau and colleagues[21] illustrated this procedure's safety regarding the temperature rise at the root surface when they used an argon laser at power settings of 1 and 2 watts.

The most widely used laser in endodontics is the neodymium:yttrium-aluminum-garnet (Nd:YAG) laser, which emits a wavelength of 1,064 nm. Owing to the wavelength's being in the near infrared range, flexible conductors can be used in narrow and curved root canals. This laser yields a bactericidal effect on root canal surfaces and in the deeper dentin layers. Studies by White and colleagues,[22] Rooney and colleagues,[23] Gutknecht and colleagues[24] and Moritz and colleagues[25] showed the high bactericidal effect of the Nd:YAG laser.

The diode laser is comparable to the Nd:YAG laser in terms of effectiveness. It emits at a wavelength of 810 nm and has comparable bactericidal capabilities.[26]

For the removal of dental hard tissue, the erbium:yttrium-aluminum-garnet (Er:YAG) and the erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) lasers provide suitable wavelengths. Emitting at 2,940 nm and 2,780 nm, respectively, these lasers act through photoablation since their wavelengths correlate closely with the absorption maximum of hydroxyapatite. When irradiated, water contained in the dental hard tissue evaporates instantaneously and ablates the surrounding tissue with only minimal thermal side effects.[27]

Although used primarily for the preparation of dental hard substances, the erbium lasers also can be used in endodontic treatment. The development of superior light-conductive materials allows for the irradiation of narrow or curved root canals. Hibst and colleagues[28] proposed that Er:YAG lasers be used in endodontics; later studies by Schoop and colleagues[29,30] confirmed Er:YAG laser's qualification.

Some articles focused on caries removal and cavity preparation using the Er,Cr:YSGG laser,[31-33] while Yamazaki and colleagues[34] and Kimura and colleagues[35] described the morphological changes encountered in irradiated root canal walls.

In our in vitro study, we examined the bactericidal, morphological and thermal effects of the Er,Cr:YSGG laser when it is used in addition to root canal treatment. To evaluate the antimicrobial effect of the laser, we performed bacteriolog-

ABBREVIATION KEY. CO_2: Carbon dioxide. **Er,Cr:YSGG:** Erbium, chromium:yttrium-scandium-gallium-garnet. **Er:YAG:** Erbium:yttrium-aluminum-garnet. **ESEM:** Environmental scanning electron microscope. **Nd:YAG:** Neodymium:yttrium-aluminum-garnet. **SEM:** Scanning electron microscopy. **XeCl:** Xenon chloride.