Endodontic re-treatment requires a complete elimination of debris and previous filling material from root canal walls. Some techniques have been described to remove insufficient root canal filling. In clinical practice, this is conventionally performed using hand or mechanical endodontic instrumentation with physiological saline solution or other irrigating agents, but sometimes also using subsonic or ultrasonic devices. The procedure is not always fully successful because some materials, such as cement, silver cones, or broken instruments, are not easy to remove. Sometimes either the instruments used for re-treatment break, or the strong mechanical action of the instruments and the high temperatures reached using mechanical devices lead to a damage of dentinal walls. Furthermore, these procedures are often tedious and time consuming.

Removing root canal obstructions – such as frac-
tured instruments, metal posts, or root canal filling materials – especially in re-treatment cases, is a complicated and time-consuming procedure. Although nowadays there are different methods available for the removal of root canal obstructions, they have many disadvantages: root fracture and the risk of perforation, substantial loss of tooth structure, length of the procedure, incomplete removal, etc. A more reliable and safer method for removing root canal obstructions is needed.

The advantage of Nd:YAG laser is that root canal fillings in the deeper portion of the root canal can be reached by the laser, a task not feasible by means of a high-speed cutting bur. Today, a wide range of laser devices is used in endodontics for diagnosis, treatment of hypersensitive dentin, pulp capping, pulpotomy, apicoectomy, root canal cleaning and shaping. However, few studies have been published on the removal of root canal obstructions using the laser beam. The aim of this study was to find out if the use of a Nd:YAG laser could improve the re-treatment of root canals. Changes that might occur on dentinal walls during laser irradiation were investigated using SEM.

MATERIALS AND METHODS

Forty permanent single-rooted human teeth, extracted because of periodontal disease from 30- to 50-year-old patients, were chosen. The teeth were placed in a 5% NaOCl solution for 10 min in order to remove organic residues. The time between extraction and analysis was not more than 3 months. During this time, the teeth were stored in a 0.9% saline solution at 37°C in a thermostatic bath (TWBS, Julabo, Germany).

The teeth were endodontically treated using Ni-Ti instrumentation (Profile, Maillefer, Switzerland) up to #25 diameter and .06 taper, and flushed using saline solution. The root canals were filled with vertically compacted warm gutta-percha and Rickert-formula endodontic sealer (Argoseal, Ogna, Italy). Then they were randomly divided into 4 groups of 10 specimens, and endodontically re-treated using different methods.

- Group 1 specimens underwent Nd:YAG laser re-treatment (Pulse Master 600 IQ-American Dental Technologies, USA) with a 1064-nm wavelength, using 100 mJ energy, a 15-Hz pulse rate, and 1.5 W of power for 3 cycles of 10 s each, with a 20-s break after each cycle.
- Group 3 specimens underwent Nd:YAG laser re-treatment using 160 mJ energy, a 35-Hz pulse rate, and 5.6 W of power for 5 cycles of 10 s each, with 20-s breaks between cycles.
- Group 4 specimens were not re-treated by laser, but only by .04 and .06 taper Profiles Ni-Ti instruments (Maillefer, Switzerland), and used as control group (CG).

In all teeth, gutta-percha removal was completed with the use of #20 manual Hedstroem and K-file instrumentation (Maillefer, Switzerland), and the root canal was flushed with physiological saline solution. The laser beam was delivered through a 200-μm-diameter optic fiber, introduced into the root canal in crown-apex direction up to 1 mm from the apex and back to the crown, rotating 360 degrees. For each tooth, 3 cycles were performed of 10 s each, with 20-s breaks between cycles. During the 20-s breaks, the root canal was irrigated with saline solution, as suggested by the manufacturer.

All the teeth were split longitudinally in half, mounted on stubs, and sputter coated with a 25-nm layer of gold in a sputtering device (Balzers SCD 050, Liechtenstein). These were then observed using a Stereoscan 360 SEM (Cambridge Instruments, Cambridge, UK) at several levels of magnification and 20 KW electron beam acceleration. A grid was used to create 100 subfields in high magnification SEM images, in order to evaluate the percent coverage of gutta-percha or debris in each microscopic field.

RESULTS

The rating system used to estimate the percentage of gutta-percha and debris was as follows: 0 = no debris; 1 = low percentage (< 50%) of gutta-percha and debris; 2 = high percentage (> 50%) of gutta-percha and debris. The results of SEM observations are given in Table 1, showing that the highest number of teeth with a score of 0 belonged to Group 3, whereas no teeth with a 0 score belonged to Groups 1 or 4. The highest number of teeth with a score of 1 were found in Group 4, while the largest number of teeth with a score of 2 were in Group 1. In Group 3, there were no teeth with a score of 2.

- Group 1: The root canal walls of teeth in this group...
are moderately clean. In higher magnification images (Fig 1), it is possible to see some open tubule orifices in the coronal third; at the same time, however, some areas are visible where the dentin surface is covered by a thick layer of debris, similar to carbonized gutta-percha (Fig 2). In the apical third, both lower and higher magnification images (Figs 3 and 4) show the presence of intact gutta-percha in root canal space. The dentin structure is not modified.

- **Group 2:** The root canal walls of teeth in this group are cleaner than those of Group 1. In the coronal third, it is possible to observe a great percentage of dentin tubule orifices appearing as small, dark/light circular zones, with some isolated debris on canal walls (Fig 5). In the middle third, a glass-like dentin surface (Figs 6 and 7) can be seen, and some residual gutta-percha is still present.

- **Group 3:** Here the debris was almost totally eliminated (Fig 8), but dentin surfaces in the middle and apical thirds exhibited some melted and re-crystallized areas (Fig 9), leading to a complete obliteration of some tubule orifices (Fig 10).

- **Group 4:** In the control group, coronal and middle portions of the root canal are clean, even if some debris is still visible (Fig 11). However, the apical third (Fig 12) shows the presence of large, scattered clumps of gutta-percha (Fig 13).

### DISCUSSION

Re-treatment is presently one of the foremost topics in endodontics. In re-treatment cases, root canal filling materials, post and cores, and fractured instruments must be removed first. There are a variety of methods
available for the removal of root canal obstructions: root canal pliers, post removers, ultrasonic devices, etc. However, none of them is satisfactory, and all have disadvantages.

While the Nd:YAG laser has been used in dental practice for many years, its maximum output energy has been limited, which has restricted its use. The principle of interaction between the Nd:YAG laser and targeted tissue is mainly based on the photothermal effect. The laser device has been evaluated in endodontics for a number of applications. The possible use of laser in endodontic re-treatment may allow better removal of inadequate root canal fillings while preserving the dentinal walls of the root canal. The small diameter of optic fibers (up to 200 µm) can easily work in the apical third of the root.

The surface effects of laser is, in all cases, the creation of craters in the center of the areas where it is
applied, a border of fused material at the rim of the craters, and cracks or fractures at a distance from the target areas.\textsuperscript{10} However, effects on dental materials vary with material and the laser parameters used.\textsuperscript{11,12}

As far as temperature elevation is concerned, some studies\textsuperscript{13,14} report temperatures increases ranging from 5° to 7°C when using Nd:YAG laser; similar results were obtained with a 245-µm fiberoptic and a Holmium:YAG laser. Using a Nd:YAG laser, some authors\textsuperscript{15} observed a maximum temperature increase of 10.3°C in the irradiated zone during 5 s exposure at 2 W power and 5 Hz impulse frequency, which did not seem to damage dental tissues.

In our study, we investigated the effects of root canal re-treatment using Nd:YAG laser (according to the manufacturer’s instructions); we used hand instrumentation in conjunction with the laser in order to avoid the accumulation of carbonized areas of dentin.
and gutta-percha in the central part of the root canal space. We did a full analysis of the results of the procedure using SEM. The use of Nd:YAG laser at lower settings (100 mJ, 15 Hz, 1.5 W) produces fairly clean root canals, but a not complete elimination of gutta-percha from dentinal walls. Dentin structure is not modified, probably because of the presence of the previous filling. In any case, lower parameters do not seem to be sufficient to prepare dentinal walls for refilling. At increased power levels (100 mJ, 20 Hz, 2 W) the laser seems to be more effective on the canal walls, cleaning them better. Higher parameters (160 mJ, 35 Hz, 5.6 W) and a longer laser irradiation produce cleaner walls, even though a significant alteration of dentin morphology is visible.

**CONCLUSIONS**

The Nd:YAG laser could be an effective device for root canal re-treatment, as long as intermediate energy parameters are used (between 2 and 5.6 W), in order to
avoid dentin structure modifications. Statistical evaluation carried out in our study shows that laser power levels should be higher than those suggested by the manufacturer. This preliminary study points out that further experimentation is needed, using different protocols and processing a greater number of samples.

REFERENCES


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