Nd:YAG laser-assisted removal of instrument fragments

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The Nd:YAG lasers tested in laboratory studies have been claimed to be able to successfully manage the removal of instrument fragments within root canals[1–4]. This is done in four ways, all correlated to temperature effects:

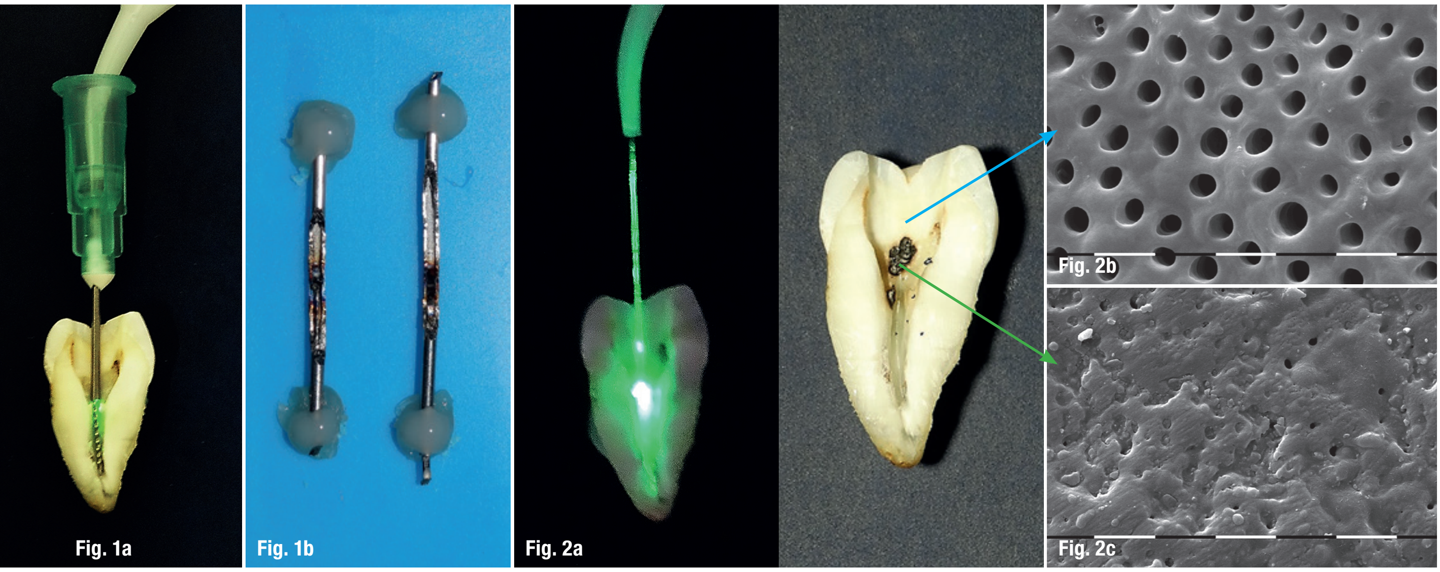
1. Laser melts the dentine around the fragment and then Hedstrom files are used to bypass and retrieve the fragment.
2. Laser melts the entire fragment.
3. Laser energy melts the solder, connecting the fractured instrument with a brass tube charged with solder and placed at the exposed coronal end of the fragment.
4. Laser welds the file fragment positioned within a metal hollow tube (e.g. Endo-Eze® Tip, Ultradent Products; Figs. 1a & b).

The removal of a claimed minimum amount of root dentine[1,2,4] can be attributed to the potential given to the user of Nd:YAG laser to distinguish dentine[1] from obstructions by the difference in acoustics produced by the two materials. Ebihara et al. observed that some orifices of the dentinal tubules were blocked with melted dentine after laser irradiation.[1] Yu et al. found that the temperature rose by 17 °C to 27 °C, but argued that, since the initial temperature was lower than human body temperature, these results were irrelevant.[2]

The findings demonstrated that a pulsed Nd:YAG laser irradiation has the capability of removing broken files. The success rate reported by Yu et al. was 55 per cent.[2] However, the thermal effects found after Nd:YAG irradiation in dry root canals were considerable (Figs. 2a–c). Thus, the focus now is on the outcomes of using a laser fibre inserted into a hollow tube (alone or in the presence of solder) both to avoid dentinal carbonisation and to achieve welding between the separated file and metal tube.

Intraoral laser welding

The intraoral laser welding phenomenon is well researched.[1–4] Even for metals that absorb well, such as steel, the laser light is initially reflected. A small percentage of the laser light is absorbed, heating the metal surface.



Figs. 1a & b: Welding of separated K-type file in Endo-Eze® Tip (18 gauge) using Nd:YAG laser irradiation at 400 mJ and 10 Hz **(a)**. Longitudinally cross-sectioned metal tubes with melted K-type files inside **(b)**. **Figs. 2a–c:** Undesirable thermal effects of Nd:YAG irradiation (3 W, 300 mJ, 10 Hz) in a dry root canal **(a)**. When the optic fibre comes into contact with the dentinal wall it can cause carbonisation and melting. SEM image of a control dentinal surface **(b)** and dentine irradiated with an Nd:YAG laser, revealing areas of melting and dentinal tubule closure **(c)**.

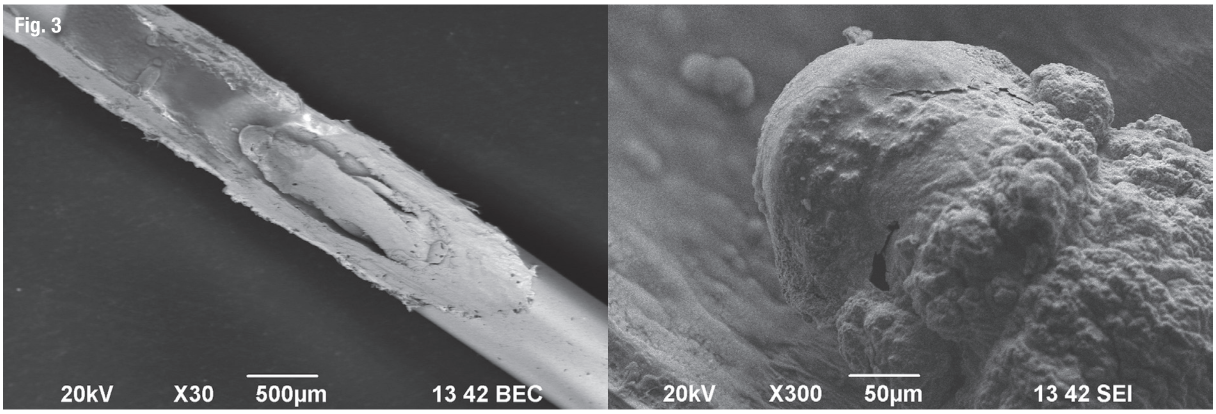


Fig. 3: SEM image of a K-type file after Nd:YAG laser irradiation at 400 mJ and 10 Hz revealing a melted metal surface with an irregular granular structure after solidification.

The increased surface temperature increases the absorption of the laser power. This creates a snowball effect, in which the material is rapidly heated by the laser, leading to melting and the consequent formation of a weld.

Hagiwara et al. performed laser welding on stainless steel or nickel-titanium files using an Nd:YAG laser in order to evaluate the retention force between the files and the metal extractor.[3] Additionally, they evaluated the increase in temperature on the root surface during laser irradiation. They reported that the retention force on stainless steel was significantly greater than that on nickel-titanium. The maximum temperature increase was 4.1 °C. The temperature increase on the root surface was greater in the vicinity of the welded area than at the apical area. Scanning electron microscopy (SEM) revealed that the files and extractors were welded together. Similar results were found by Tomov (unpublished data; Fig. 3).

In vitro study

Cvikl et al. used a brass tube charged with solder and placed at the coronal end of the fractured instrument in their *in vitro* experiment.[4] Nd:YAG laser energy was used to melt the solder, connecting the fractured instrument with the brass tube. They reported that the fractured endodontic instruments were removed successfully in 17 out of 22 cases (77.3 per cent) in which more than 1.5 mm was tangible. When less than 1.5 mm was tangible, the removal success rate decreased to three out of 11 cases (27.3 per cent).

These results obtained from *in vitro* experiments indicate that the laser welding method is effective in removing broken instruments from root canals, but its efficacy has to be further verified in clinical trials.

Literature

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Im Zuge von Laborstudien wurden Nd:YAG-Laser bereits erfolgreich, mit dem Ziel Instrumentenfragmente aus Wurzelkanälen zu entfernen, genutzt. Dies kann auf vier verschiedene Arten erfolgen, jeweils korrelierend mit temperaturinduzierten Effekten. Der Autor betont, dass in früheren Studien von geschmolzenem Dentin verschlossene Dentintubuli festzustellen waren, welche durch die Nd:YAG-Laserbestrahlung verursacht wurden. Die thermalen Effekte erwiesen sich besonders bei trockenen Wurzelkanälen als erheblich. Um diese Dentinkarbonisierung und -schmelze zu vermeiden, legt sich der Fokus nun verstärkt auf Laserschweißen, d.h. das Fragment wird (meist mithilfe von Lötmetall) innerhalb einer Messingröhre unter Verwendung von Lichtleitfasern gebunden und entfernt. Im Ergebnis von In-vitro-Experimenten erwies sich diese Methode des Laserschweißens als effektiv im Entfernen abgebrochener endodontischer Instrumente aus Wurzelkanälen. Ihre Effizienz gilt es, in klinischen Versuchen weiter zu belegen.