Lasers in Endodontics – A Practical Overview

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Summary: This article gives an overview of the practical procedure for laser-assisted endodontics and is an excerpt from the chapter in the book "Lasers in Dentistry" by Andreas Moritz et al, which will be published in February 2005 by Quintessenz.

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The importance of endodontic treatment in modern dentistry has increased significantly. Patients are asking dentists to save their teeth and expect the results to be permanent, with no subsequent complications. Many teeth that are endodontically treated are subsequently crowned, or involved in expensive reconstruction procedures, making it imperative that endodontic techniques can be relied upon for a satisfactory longterm prognosis.

The standards of endodontics have been constantly raised in the last 25 years by research and interest among practitioners, particularly at universities. Preparation techniques – both manual and power-driven – have been refined, along with filling materials and their placement in the root canals. Among the more important advances which have improved endodontic treatment are the microscope and electronic root-canal length measuring devices. However, many consider the recent development and use of lasers as the most exciting advance in endodontic treatment.

Different lasers are used in root canal preparation, cleaning of the canal walls, disinfection of canals and surrounding dentinal tubules, removal of the smear layer and debris, and sealing of tubules. Thus, the laser is effective in eliminating bacterial infection and preventing its recurrence, and when used in conjunction with traditional techniques, it will significantly increase the long-term success rate of endodontic treatment. In the following section, the current procedure for laser-assisted endodontics shall be explained.

After taking the medical history and conducting a precise clinical examination with radiographic analysis, the decision for laser treatment is made. The preparation for laser-supported endodontics does not differ substantially from the conventional steps in endodontics. From the radiographs, the anatomy of the tooth to be treated can be studied. The approximate working length is calculated: this is the measured length from the root tip to the selected point of reference. To avoid over-instrumentation, this length is reduced by 1- 2 mm.

After placing the rubber-dam, the root canal treatment per se starts.

Laser-supported root canal treatment is described in the following in four sections.

1. Preparation of the entrance cavity
2. Root canal preparation
3. Laser treatment
4. Root canal filling

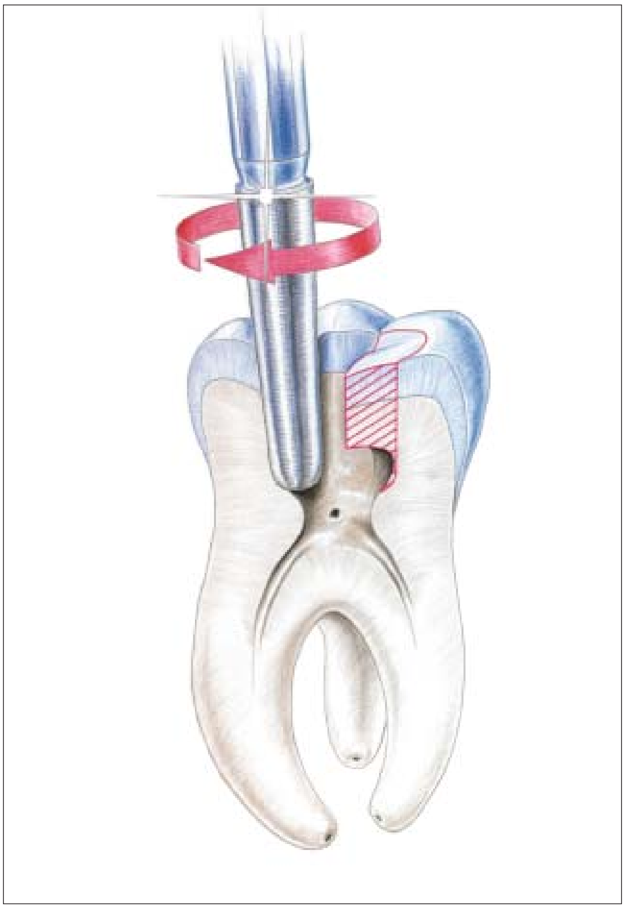

Fig 1 Preparation down to the pulp chamber is done with conical rounded diamond burs.

Fig 2 After opening up the pulp chamber, the pulp roof and the surrounding tooth parts are removed with a round bur.

1. PREPARATION OF THE ENTRANCE CAVITY

To prepare the entrance cavity, the pulp chamber roof with its overhanging parts and the crown pulp are removed, and the root canal entrances are prepared.

The preparation of the entrance cavity depends on the particular anatomy of the tooth which is being treated. A correctly selected entrance is an important condition for a good preparation. With anterior teeth and canines, the entrance is chosen from the lingual and/or palatal aspect, with the incisal edge remaining untouched. The outline of the entrance cavity corresponds in form to the dentin shape. Premolars and molars are entered from the central occlusal surface. Here the outline form also corresponds to the tooth profile.

By using conical rounded diamond burs, the cavity is prepared to the correct depth (Fig 1). After opening up the pulp chamber, the pulp roof and the surrounding tooth parts – if forming an obstacle for root canal preparation – from the center to the periphery are removed with a round bur (Fig 2). After that, the canal entrances are sought with a pointed probe without using pressure. If the operator is working without optical assistance, hard to find entrances can be found using methylene-blue dye.

2. ROOT CANAL PREPARATION

According to the German Society for Tooth Conservation (August 1999), root canal preparation is defined as preparing the root canal for a root canal filling, ie, removal of tissue remnants and bacteria, and extending and shaping the root canal.

We differentiate biomechanical preparation (use of instruments to uncover, clean, extend and shape a root

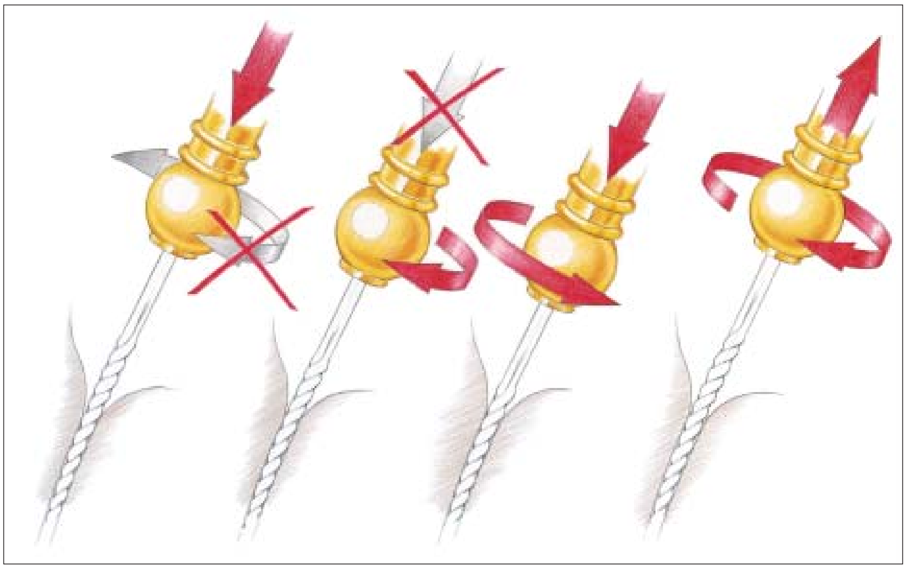

Fig 3 Balanced-force technique.

canal, usually in connection with rinsing solutions) from chemomechanical preparation (intracanal use of chemicals for rinsing, eliminating and neutralizing bacteria, tissue remnants and toxins in combination with the biomechanical preparation). Preparation can be done manually or mechanically.

The preparation differs depending upon the root canal curvature. For straight canals, manual preparation is chosen, and for moderate to strongly curved canals, a combined mechanical-manual method is used.

Manual preparation can be divided into two types, depending on the method of preparation: the apical-coronal method, determining the working length and conical preparation of the root canal in the coronal direction; the coronal-apical method, conical extension of the coronal root canal portion, determining the working length and conical extension in an apical direction.

Apical-coronal Methods

Step-back technique

The goal of this technique is to accentuate the conicity of the canal. Obturation is facilitated by this reshaping and a lateral condensation technique is possible. The risk of perforation and stage formation is reduced, because less flexible instruments of increasing diameter are not used in the area of the largest curvature.

Procedure: prepare canal entrances, remove pulp tissue with an extirpation needle, and determine the working length. The first instrument that has friction on its full length in the canal is called the initial apical file, IAF. Designated extension of the canal is ca 3 to 5 ISO sizes. The last file that is brought into full working length is called the master apical file MAF.

Depending upon the canal curvature, the apical third of the root canal is extended conically by means of the step-back technique. In straight canals, instruments of ascending size are shortened by 0.5 mm below working length, and in curved canals, by ca 1 mm.

The last instrument used is called the final file, FF. Before changing instruments, the MAF should be inserted to working length and the canal should be rinsed thoroughly with NaOCl.

Balanced forces method

The application of this technique requires files with a triangular cross section and a non-cutting point, so-called Flex R files. The advantage of this technique is that there is hardly any preparation-related deviation, especially in the apical third of the canal.

Procedure: The file with the non-cutting point is inserted into the canal up to the first sign of friction. A clockwise quarter-turn, followed by an apically directed rotational movement of 360 degrees counterclockwise is carried out. Afterwards, the instrument is removed by clockwise rotation in the coronal direction (Fig 3). The canal is then cleaned and rinsed thoroughly with NaOCl.

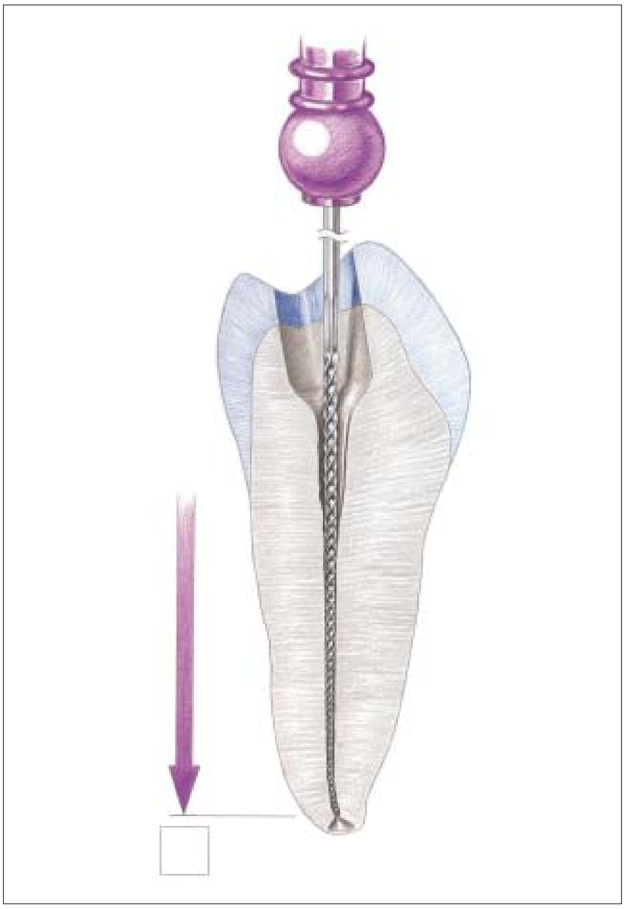

Fig 4 The possibility of passing down the canal is checked with a file (ISO 0.08 or 0.10).

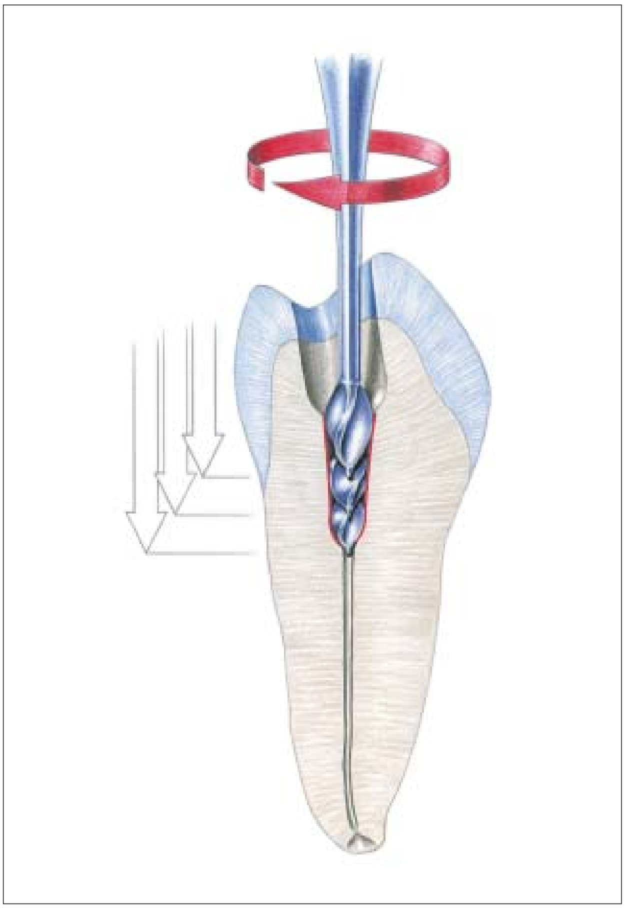

Fig 5 Enlargement and extension of the canal entrance using Gates-Glidden drills. This facilitates further instrumentation, because the subsequent instruments encounter less curvature.

Coronal-apical Methods

The fundamental advantage of this method is that with coronally limited instrumentation, inflamed pulpal tissue and bacteria are not brought into the apical region. Further, the coronal extension facilitates the cleansing of the canal, and because of this, the danger of blockage by broken off dentin splinters is reduced.

Step-down technique

Procedure: Initially prepare the coronal and middle third of the canal or up to the beginning of the canal curvature by gradually increasing the diameter of the instruments. Afterwards, the canal entrance is shaped with Gates-Glidden instruments. The working length is then established and the preparation continued into the apical third of the canal with instruments of smaller diameter.

The advantage of this method is that with the initial extension, the instruments used in the coronal portion have less wall contact, and can therefore be used more efficiently in the apical region. The risk of a canal straightening is thereby minimized.

Crown-down pressureless technique

In this technique, a straight entrance is first created with Gates-Glidden drills. Following that, the canal is extended by rotation without apical pressure, with a file of ISO size 35 which is inserted up to the friction point. This procedure is repeated with instruments of decreasing diameter up to the point where the working length is reached. After radiological checking of the working length, the apical third is extended in the next cycle.

Double-flared technique

Here, a combination of the step-down and step-back technique is used and the efficiency is increased by Gates-Glidden drills.

Procedure: With instruments of relatively large diameter, eg, ISO 80, the canal is gradually prepared from the coronal towards the apical. The diameter decreases step by step until the working length is reached. Following that, the canal is prepared conically with the help of the step-back technique, so that the conicity increases.

If there is a straight canal (measured by the Schneider Method),[1] the possibility of passing down the canal has to be checked with a file (ISO 0.08, 0.10) (Fig 4), and afterwards the entrance is extended with a Gates-Glidden drill (Fig 5).

On a small radiograph, a line is drawn through points A and B, referring to the root axis (longitudinally). Point A equals the canal entrance and point B is where the canal moves out of the straight line. The angle enclosed by those two lines with the angle point B equals the curvature of the canal. Schneider divides canals into three categories.

1) straight canals, 0 to 5 degrees
2) moderately curved canals, 10 to 20 degrees
3) strongly curved canals, 25 to 70 degrees

The remaining root pulp in the canal is removed with an extirpation needle, and the canal is rinsed with NaOCl. Now the working length is measured, and confirmed with a radiograph. This is done with a file of ISO 15 that is connected to an electrical length-measuring tool; with the balanced force technique, the total working length of the root canal is prepared (Fig 6). After putting the rubber stops on the reference points, a radiographic measurement is made.

After radiological confirmation and fixing the definitive working length, the canal is prepared with instruments of increasing size, using the balanced force technique. The laser treatment can only be done after apical extension using a minimum size of 35 to 40, so that a friction-free insertion of the fiber up to the apical stop is possible even in strongly curved canals. After the canal is extended to the size of ISO 35 to 40, all

Fig 6 Using a file of ISO 15 and the balanced-force technique, the attempt is made to make the canal accessible up to the full working length.

further instruments are shortened by 3.5 mm before being inserted into the canal (step-back technique).

To prevent clogging of the canal with dentin debris, a lubricant (EDTA) should be used and the canal also rinsed with NaOCl. The effect of rinsing only reaches a few mm from the needle tip, and sufficient penetration depth is important. It may be helpful to put a silicon stop on the rinsing needle to control the penetration depth.

The preparation of a canal that is curved to a moderate or high degree on the Schneider scale is more complex. Although the sequence of treatment may be the same as in straight canals, a combined mechanical-manual technique is suggested. The reason for this is not only time savings, which only has to be taken into account by an experienced user.

The actual mechanical preparation is done with nickel titanium instruments, which – due to material

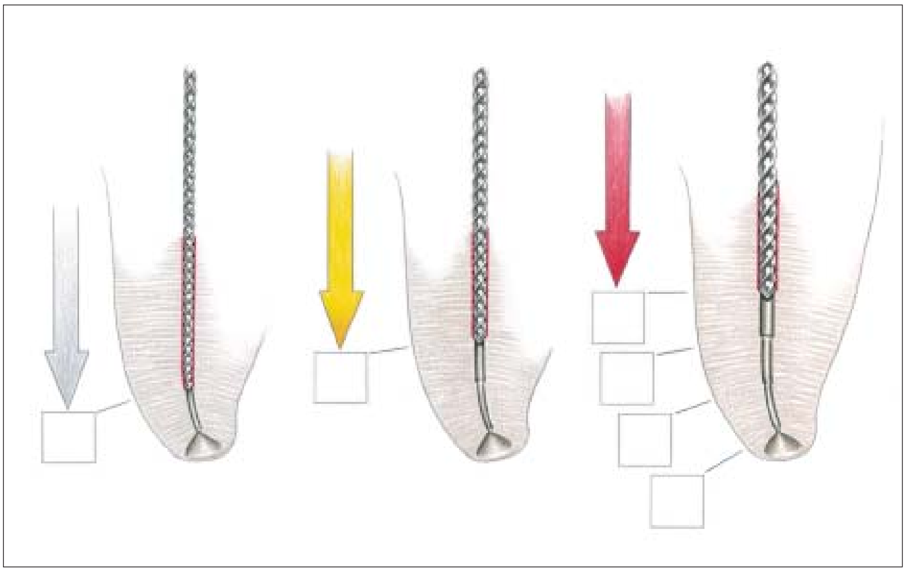

Fig 7 After the canal has been instrumented to a width of ISO 40 at full working length, subsequent instruments are introduced into the canal to a working length reduced by 0.5 mm.

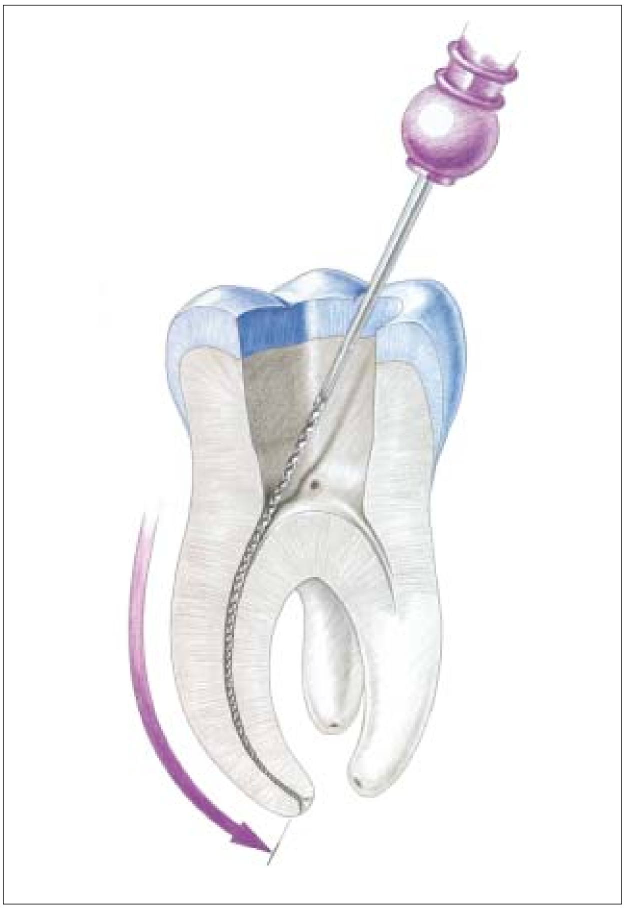

Fig 8 Passage check with a 0.10 file.

flexibility – are able to follow the curvature of the root canal. In addition, the higher conicity of these instruments enables a quick extension of the canal and the circular removal of dentin, because they are used in a rotational manner.

First, the attempt is made to pass a file (ISO 0.08, 0.10) down the canal (Fig 8), and then the entrance is extended and straightened mechanically with an intro file. A special handpiece in a torque-control steered motor is recommended. For mechanical preparation, a chelator is used to reduce the smear layer that is produced during preparation, which also lubricates the instruments.

The next step is the preparation of the coronal canal portion, using an instrument of size 06/30 (Fig 9). After another rinsing with NaOCl and a change of instruments to size 06/25, the penetration advances to the apical third of the canal. This should be done without using any pressure, always keeping the canal damp with a chelator.

The preparation of the apical third is now done mechanically and manually. Up to three mm before the foramen, the canal is prepared mechanically with an instrument of size 04/30. The lower conicity of this size instrument means that there is no friction over the full length of the canal wall. The last unprepared part of the canal is now prepared manually (Fig 10). Starting with a file ISO 15, the canal is penetrated to working length and extended to a minimum of ISO 35 to 40. All further instruments are now reduced in length (1 mm) and inserted into the canal to extend the apical region conically, using the step-back technique.

After finishing the conventional preparation and

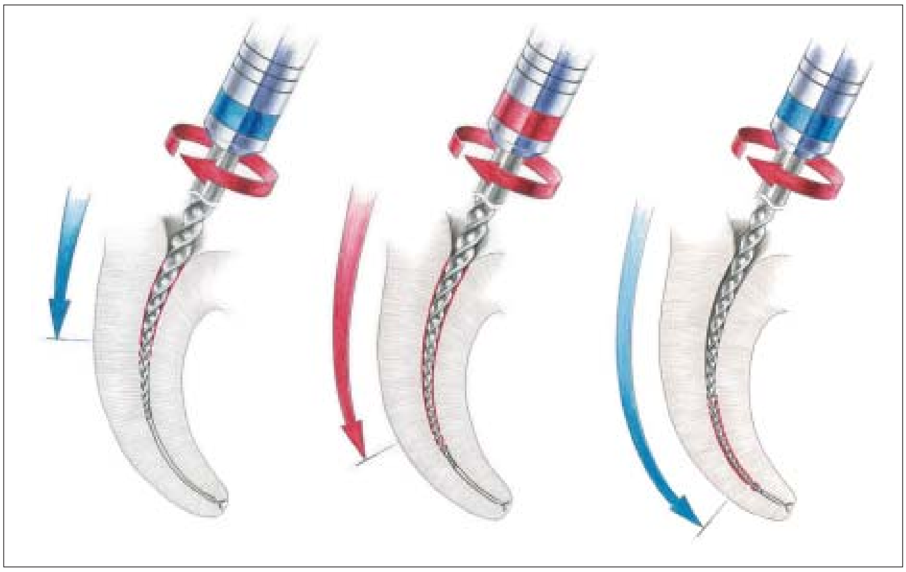

Fig 9 Preparation of the upper canal portions up to 3 mm of the expected apex.

rinsing the canal, it is dried with sterile paper points. The laser treatment can now begin.

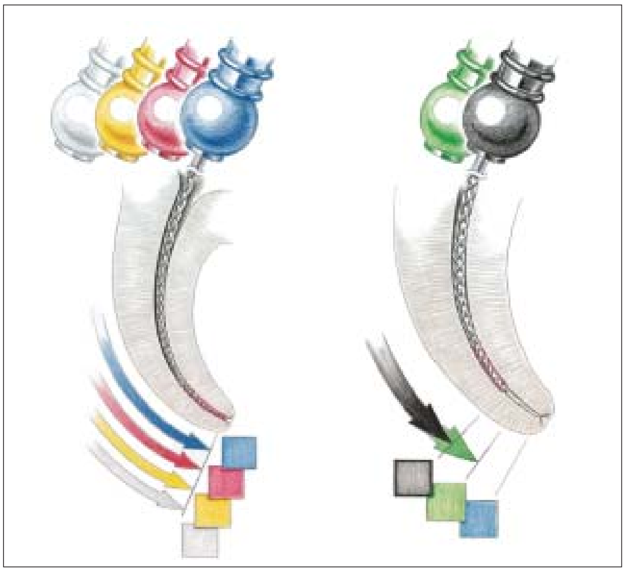

Fig 10 Preparation of the remaining canal portions with hand instruments.

3. LASER TREATMENT

After finishing the conventional preparation, and extensive rinsing and drying of the canal with sterile paper points, all prerequisites for laser treatment have been met.

The laser fiber is inserted into the canal, after the working length has been marked with a rubber stop on the fiber, and the laser is activated. Special care should be exercised so that the fiber does not remain at the apical stop for longer than 1 s, since the temperature will rise to critical levels (see standard settings).

Subsequently, the fiber is pulled from apical to coronal in circular movements to cover the whole root dentin (Fig. 11). This procedure is repeated at least 3 times.

An experienced dentist can "feel" the laser, ie, with the pulsed laser one can distinguish the pulse noise of a wet from a dry canal, and detect whether there was any incorrect movement (eg, over-instrumentation) of the fiber.

After finishing the laser treatment, the canal is filled with calcium hydroxide and sealed with Cavit or glass-ionomer cement to prevent bacterial invasion until the next appointment. Clinical experience has shown that at least two sessions are needed for optimal laser-supported root canal treatment. With only one treatment session, there is the risk of not sufficiently sterilizing the canals and surrounding dentin. In some cases, the bacteria may actually increase after the first treatment, but after a second session of irradiation, clinical sterilization is achieved.

It is highly probable that an after-effect following laser irradiation will occur (this "post-laser effect" can be compared with the "post-antibiotics effect"). Bacteria which are irradiated with lower light intensities show cell membrane damage. Even if this does not re-

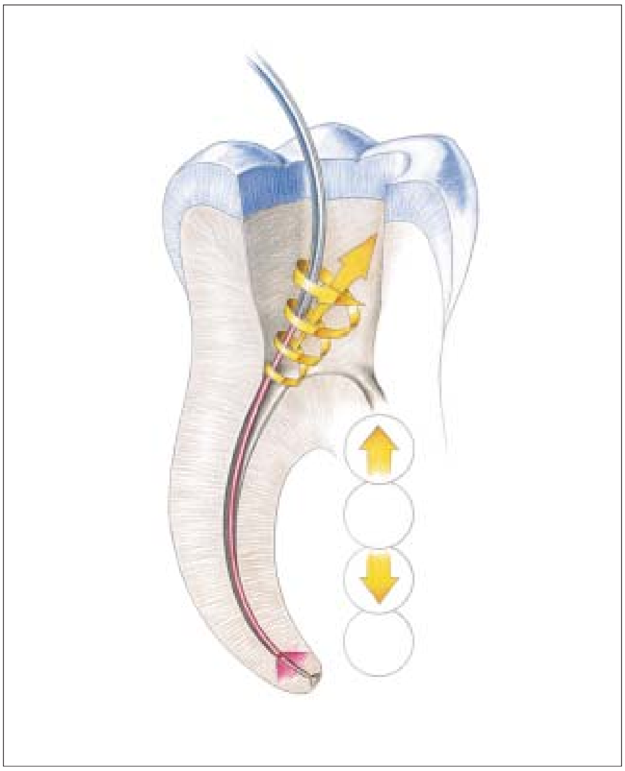

Fig 11 The fiber is pulled evenly in a circular motion from apical to coronal, in order to reach the entire root dentin. This procedure is repeated at least three times.

sult in cell death, it has an effect on the survival of the bacteria. Their general resistance towards changes in their environments is reduced and their sensitivity towards chemical disinfectants used synergistically is increased. With repeated irradiations, a cumulative bactericidal effect is reached.

4. ROOT CANAL FILLING

A definitive root filling after the third irradiation treatment is suggested (an interval of 3 days is recommended between the appointments). In extremely difficult cases, additional sessions may be necessary.

The ISO size of the MAF is the size chosen for the gutta-percha point. The master point is slightly covered with sealer and brought into the canal up to the full working length. With lateral condensation of the master point using a spreader, space is created for the extra points. The size of the spreader will also determine the ISO size of the extra points, and the coronal third of the root canal should be filled with these extra points.

Finally, the excess gutta-percha points extending from the canal are removed with a warm excavator and the coronal part of the canal is sealed by vertical condensation.

The goals of a root canal filling according to the ESE are:

– to exclude the passage of microorganisms and liquids along the root canal
– to fill out the entire duct system, not only the main canal to the apex but also to close the dentinal tubules and accessory canals.

The requirements for a root canal filling material are extensive, as follows: biocompatibility, dimensional stability, water insolubility, small moisture absorption, radio-opacity, easy application and removal. At the present time, these requirements are best fulfilled by gutta-percha. Gutta-percha is the dehydrated sap of the gutta-percha tree. Besides the gutta-percha matrix, the points also contain barium sulfate as an x-ray contrast media, and as fillers there are waxes, zinc oxide, coloring materials and trace elements.

To compensate for small irregularities and to seal the tubule system, the gutta-percha points are inserted with a sealer into the canal. The sealer also acts as cement.

After the treatment, a complete radiographic documentation is carried out, to begin a radiographic record monitoring the periapical healing in the bone and periodontal tissues.

REFERENCE

1. Schneider W. A comparison of straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271-275.

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