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State of the Art in Mechanical Root Canal Preparation – A Prerequisite for Successful Laser-assisted Endodontolgy

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Abstract: In modern dentistry, reliable endodontic treatment is increasingly important. Many procedures have been developed in recent years in order to improve the treatment possibilities. For instance, the laser-supported disinfection of root dentin has brought a major advance. Whatever technique is applied for infection control and the achievement of a tight root canal seal, the indispensable basis for successful endodontic treatment is a dependable root canal preparation. In general, root canal preparation means accessing the root canal system and performing shaping and cleaning of the canals. Nowadays, it is recommended to shape and clean with a combination of chemical and mechanical methods. Another important part is the disinfection protocol using various irrigations, medication, and ultrasonic or laser devices. To use these methods, it is necessary to obtain access to the root canal system and perform a mechanical root canal enlargement. This article presents the preparation of an ideal access cavity and the general working principle of mechanical root canal treatment with nickel-titanium instruments and the crown-down technique. Finally, guidelines for safe working conditions with the presented technique are given.

Keywords: root canal preparation, mechanical, crown down, access, nickel-titanium files.

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When it is not possible to fulfill the first endodontic goal of keeping an endodontically compromised tooth vital, root canal treatment is required to establish the further functionality of the tooth with a good long-term prognosis. In general, root canal treatment means obtaining access to the root canal system, shaping and cleaning the canals, and filling the canals and access cavity tightly. Nowadays, it is recommended to shape and clean with a combination of chemical and mechanical preparation methods.[1] The purpose of this article is to provide an overview of the state-of-the-art method of mechanical root canal treatment.

First, it is essential to know whether the root canal system of the tooth in question is infected or not. In the case of an irreversible pulpitis without the suspicion of a bacterial infection, the treatment should be finished in one visit under controlled aseptic conditions to prevent the canal system from becoming contaminated with bacteria or their by-products. When, on the other

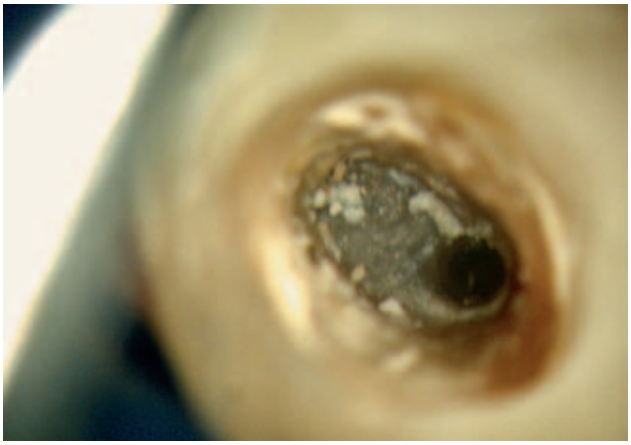

Fig 1 Access preparation of mandibular 2nd premolar: Notice eccentric location of canal orifice.

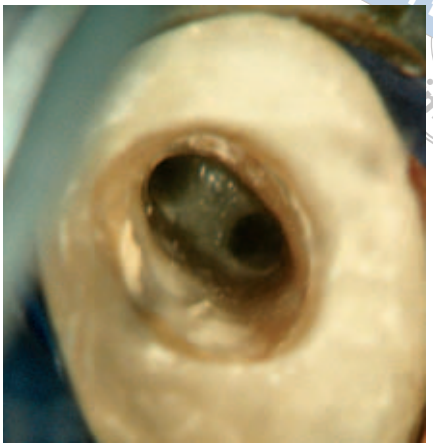

Fig 2 Same tooth after enlargement of the second canal.

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hand, a bacterial infection is obvious – as in necrotic teeth, caries profunda, and apical peridontitis – the main aim, in addition to aseptic working conditions, should be to use the best disinfection possible to eliminate as much bacteria and infected material as possible from the canal in order to prevent or eliminate apical peridontitis.[2] Aseptic conditions can be easily established by removing residual caries, making a tight temporary filling, and using rubber-dam. For the chemomechanical preparation, different irrigants (NaOCl, EDTA) and root canal instruments are required.[3] To obtain the highest possible disinfection, further irrigants (CHX, MTAD), ultrasonic irrigation, intracanal medications (CaOH, CHX-gel), and the application of laser irradiation are currently used.[4,5]

Next, it is necessary to prepare a good access cavity and find all main canals that need preparing for the desired following treatment protocol.

Access Preparation

The preparation of the access cavity is the first step of the root canal treatment. It is not only important for locating all canal orifices, but also for the further mechanical preparation of the root canals, because dentists do not always perform root canal treatments on teeth without crowns. It is therefore mentioned here in combination with the mechanical preparation.

The aims of a good preparation are to make a trepanation of the pulp chamber and remove the whole roof to establish a straight line access (Figs 1 and 2). Taking the anatomy of the tooth into consideration, the outer line of the access cavity should correspond with the outer line of the tooth at the cementoenamel junction.[6] This seems optimal for making a straight line access and opening the whole pulp chamber by keeping the loss of tooth structure to a minimum. Vertucci[6] has given some guidelines for locating the canal orifices:

- The color of the pulp chamber floor is always darker than the walls.
- The canal orifices lie equidistant from a centered mesio-distally drawn line on the chamber floor, except for the maxillary molars (Fig 3).
- The canal orifices are located at the junction of pulp chamber floor to walls.
- The canal orifices are located in the corners of the floor-to-wall junction.

After locating the canals, an enlargement of the orifices should be done to remove further dentin formations that impede a straight canal access (Fig 4). This can be a fluent crossing to the main canal preparation. Therefore, the most commonly used instruments are Gates Glidden burs or highly tapered intro files by different manufacturers. The important thing in using these instruments is to be aware of preparing away from the furcation of the tooth to avoid a perforation. They should always be applied in the direction of the canal that is being instrumented at the moment (eg, a mesio-buccal canal is prepared with a movement in the mesio-buccal direction).

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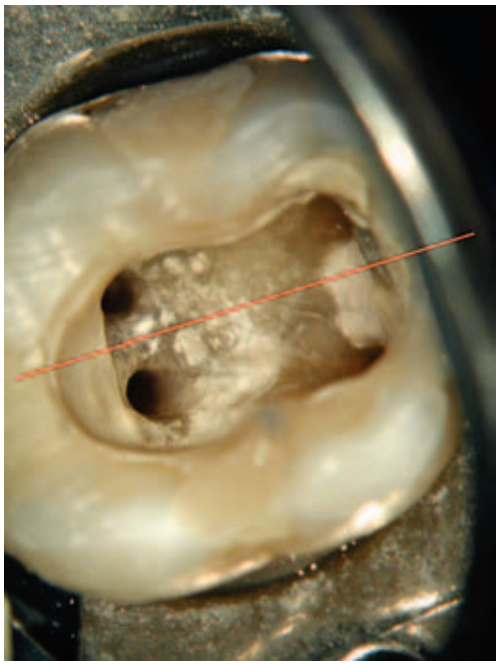

Fig 3 Mandibular first molar with four canals.

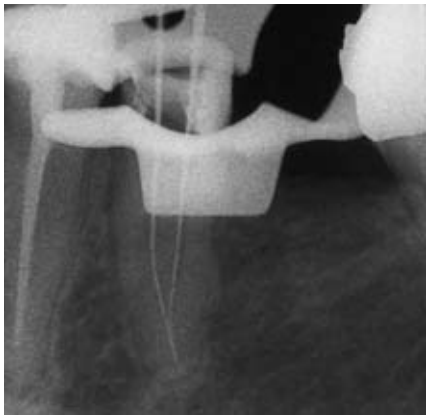

Fig 4 Radiograph of mandibular 2nd premolar: files have straight line access.

Mechanical Preparation

As stated above, the mechanical preparation of the root canals is only one part of the whole root canal treatment and is only efficient in combination with chemical components for lubrication or removal of smear layer, and chemical or physical components for the optimal disinfection of the canal system.

The main aims of mechanical preparation are:[7]

- Removal of vital and necrotic tissue from the main root canals
- Avoidance of overpreparing and extruding necrotic tissue or infected compounds out of the root canal
- Preparation of sufficient space for irrigation, medication and ultrasonic or laser application
- Maintenance of the location of the apical foramen and canal anatomy
- Maintenance of the anatomical root canal course
- Avoidance of iatrogenic damage to the canal system
- Preparation of the root canal for obturation
- Avoidance of further irritation and/or infection of the periradicular tissues.

To achieve all these aims can be a difficult exercise, and many instruments and techniques have been developed to this end. One crucial factor in root canal preparation remains the complex root canal system itself, which differs from tooth to tooth and has a variety of expressions. Thus, it is of primary importance to know the anatomy as well as possible. Secondly, it is important to know the instruments and in which technique they are used best. Finally, no one instrument or method alone is suitable for all the different varieties of root canals.

Root Canal Anatomy

To acquire information on the root canal anatomy, it is useful to take and examine pre-treatment radiographs (Fig 5) and explore the canal with small stainless-steel files to see how they are deformed in curved canals (Fig 6).

Further important points include:

- Number of canals expected
- Joining or dividing of canals at some point in the root
- Existence of natural or iatrogenic hindrances
- Curvature and radius of the canal
- Presence of an isthmus between two canals

Fig 5 Mandibular 2nd premolar: the abrupt loss of canal visibility on the radiograph can indicate a dividing of the main canal.

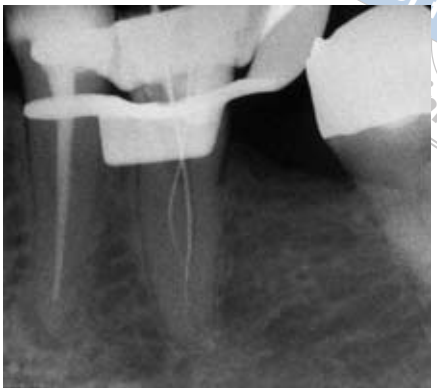

Fig 6 Mandibular 2nd premolar before establishing straight line access.

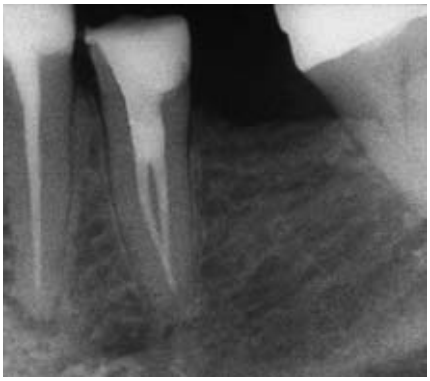

Fig 7 Mandibular 2nd premolar prepared with NiTi files using the crown-down technique.

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Instruments and Techniques

The most commonly used files are stainless steel, eg, k-files, k-reamers or Hedstroem files, which have a taper of 2% and differ mainly in the angle of their cutting edges. These files are very hard and have a good cutting efficacy.[8] Furthermore, it is possible to bend them as needed to explore canals with steps or strong curvatures. However, such files are also stiff, especially in the larger sizes, which can lead to straightening of the canal, transportations, elbow- and zip formations.[9,10] Therefore, the suggested usage of these files is by hand and with the "step-back" technique, where the working length at larger sizes is reduced every time a new file is inserted into the canal. This technique also allows preparing a more tapered canal to increase the effectiveness of the irrigants used.

With the introduction of nickel-titanium (NiTi) instruments, some of these problems seemed to be solved, because of their higher flexibility and at the same time enough hardness to cut dentin effectively. Their higher flexibility is due to a high E-modulus, which gives them a three-fold higher flexibility than stainless-steel files and is also termed "super or pseudo elasticity".[11] The suggested usage of these files is a combination of rotary instrumentation and a torque controlled motor.

At the moment, many manufacturers offer a whole array of NiTiinstruments with many different designs. The instruments can have an active or passive cutting ability. The properties of the material also make it possible to produce files with greater tapers. The tapers of the instruments reach from 2% to 12%. Single-tapered instruments as well as multiple tapers in one file are present. What they all have in common is the suggested usage with the "crown-down" technique.[12]

Crown-Down Technique

In this technique, a preparation is done from coronal to apical. The canal is mentally divided into three parts (coronal, middle, apical). For the initial coronal preparation, files with high tapers (8% to 12%) or, as mentioned

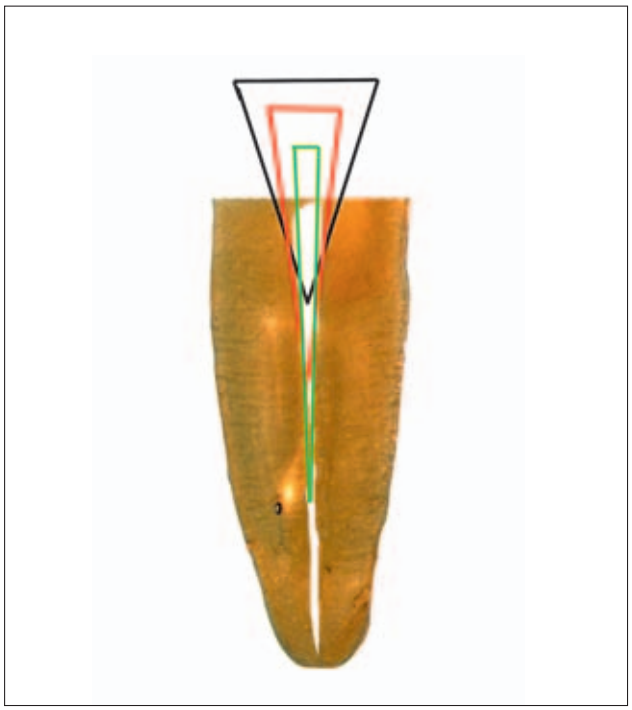

Fig 8 Illustration of the sequence: reduced taper and constant file size.

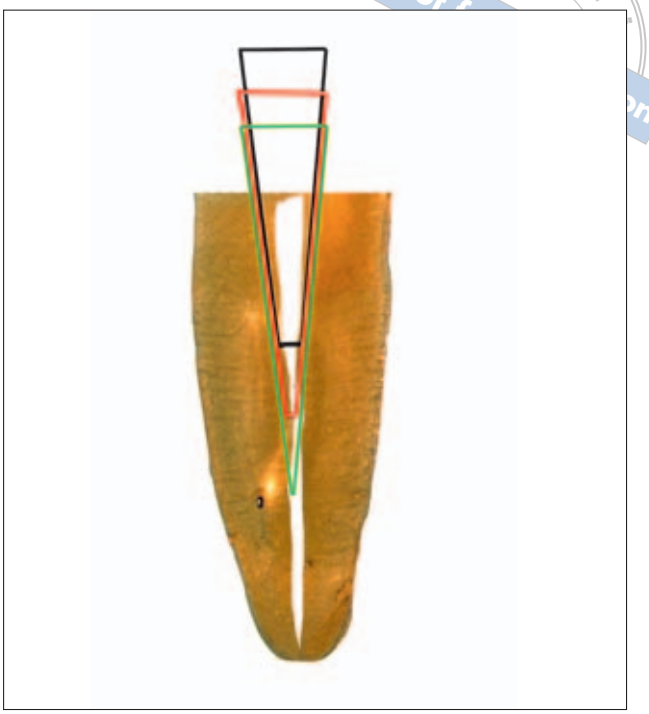

Fig 9 Illustration of the sequence: constant taper and reduced file size.

above, Gates-Glidden burs for the first few millimeters are used. For the further coronal and middle canal preparation, either the tapers of the files are reduced (from 8% to 4%) or the sizes, while using a constant taper.[13] The advantage of this is that the maximum stress on the files is always located in the coronal part, where their diameter is larger, and not at the file tip. Furthermore, enough space is created in the coronal and middle third when it comes to the instrumentation of the apical portion of the canal. Without stressing the files from the coronal, the preparation of the last canal third to the required size seems safer and more efficient.

Moreover, this technique increases the efficacy of chemical irrigation, and necrotic tissue and infected debris are removed sooner from the coronal and middle part. Furthermore, less straightening of the canal is reported[14,15] and better tactile contact to the apical region seems obvious (Fig 7). The modern NiTi file systems are generally based on using the sequences variable taper and unvaried sizes (Fig 8) or constant taper and variable sizes (Fig 9). Usually, a combination of of the two sequences exists in the setup sequences by the different manufacturers.

When using rotary NiTi files, a higher file fracture rate is reported than for stainless steel files, but clinical evidence has not yet been published.[7]

File Fracture

To avoid this problem during mechanical root canal treatment, a few things have to be considered every time a rotating NiTi instrument is used in the canal, regardless of file system. First of all, a glide path with stainless-steel files (ISO 15 or 20) should be created in every canal, so the subsequent NiTi instruments can glide along the path without using much pressure.[16] Further, the use of a torque-controlled motor with constant speed and a low torque mode seems to be required as well as cleaning of the files after every usage in the canal and lubrication via irrigation or gels. It also should be considered that the greater the curvature, the file taper, the file size or the smaller the radius of the canals, the greater is the risk of file fracture. Moreover, files which have been used in more strongly curved canals have been exposed to much more stress than others, so further usage should be considered very carefully.

Taking these precautions into account and using the files with the suggested technique, an acceptable clinical result and safe usage can be achieved.

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