Blockbook "Endo 1"
Endodontics 1
Part 1: Reader
2023-2024 B3Td1t

Endodontics 1
B3Td1t

Blockbook Endodontium 1-2023-2024

Dentistry

September 2023

Reader

Table of Contents: *Part 1: Reader*

1 Orientation on the block

Endodontium 1, B3Td1t, course year 2023-2024, 6 credits

Main objectives

1. You can describe the etiology of diseases of the endodontium and the tissues connected to it and know which targeted preventive measures you can take to prevent diseases.

2. You can detect disorders of the endodontium and the associated diseases diagnose tissues and indicate the associated therapy. You can distinguish between the treatment of the vital pulp and the necrotic pulp infected pulp.
3. You can describe and substantiate the choice of instruments and materials during root canal treatment based on the material science aspects.
4. You can indicate the possible follow-up treatments for endodontic therapies and indicate.
5. You can describe the various endodontic treatments and indicate the aspects that are important for the treatment result.
6. You can perform the various phases of the root canal treatment in a phantom setup to carry out.
7. You can indicate the indication for internal teeth whitening and the carry out the procedure.
8. You can describe the various endodontic treatments and indicate the aspects that are important for the treatment result.

Partial objectives

Cognitive (Exam)

1. You can diagnose the etiology of diseases of the endodontium and the tissues connected to it and justify your choice of preventive measures to prevent these diseases.

2. You can diagnose the diseases of the endodontium and the tissues connected to it.

3. You can indicate therapy for diseases of the endodontium and the tissues connected to it.

4. You can indicate possible follow-up endodontic treatments
5. You can indicate the indication for internal teeth whitening and the carry out the procedure.

Preclinical (Assessment forms 1, 2 and 3):

1. You can describe the various endodontic treatments and indicate the aspects that are important for the treatment result.
2. You can perform the various phases of the root canal treatment in a phantom setup to carry out.
3. You can treat patients, in theory, as well as simply classified perform root canal treatments in various types of teeth.

Global content

Endodontics is the practical implementation of endodontics. It can be interpreted as a collective term for pulp treatments. As such, this includes the prevention of pulpal and periapical disorders, in addition to endodontic treatments such as pulp capping, pulp amputation, root canal treatment and endodontic surgery.

This block discusses the various factors responsible for the development of pulpal or periapical disorders, their prevention and the indication for carrying out non-surgical and surgical endodontic treatments. The treatments themselves, the use of medications, endodontic follow-up treatments and evaluations.

In addition to the theoretical foundation, you will practice performing root canal treatment during the preclinical practicals.
All in all, endodontics as a whole is aimed at combating pulpal and periapical disorders and pain, while preserving the tooth in question; all this to prevent serious (systemic) consequences of these conditions for the patient.
This makes it a tough and strenuous discipline. In block B3Td1T/Endodontics 1 you will experience these aspects during the cognitive and (pre)clinical training.
Endodontics can be considered a pillar of dentistry.

The block is divided into a cognitive and a practical part. During the cognitive part you will acquire the knowledge you need to adequately diagnose endodontic problems, indicate treatment, carry out that treatment and evaluate the result. In the practical part of the block you will carry out the various phases of the root canal treatment.

The 'Endodontium 1' block builds on the education from the first and second year of study and is linked to blocks from the third year of study. The blocks 'Oral diagnosis', 'Diagnostics and planning' and the 'Pain' block come together in the diagnosis of disorders of the endodontium and the tissues connected to it. The etiology of these disorders is further expanded after the blocks 'Restoration of teeth 1 & 2', 'Function and recovery of function', 'Periodontium' and 'Dents'.
This is supported by the education from the blocks of the 1st year 2nd and 3rd year . Cognition continues in block Endodontium 2.

Block Endodontium 1 is a sub-skill block in which the performance of canal treatments is trained exclusively on phantom. In the master phase of the study, the skills trained in Endodontium 1 are performed on patients in a clinical setting in the master clinic. The Endodontium 2 block builds on the preclinical training of complex endodontic treatments (DETI B, CEB II and III) with new tools and techniques.

The fifth and sixth year profile education will discuss the treatment of complex endodontic problems in the clinical setting.

All in all, endodontic treatments are aimed at combating pain and inflammation, preserving the affected tooth and preventing serious systemic consequences of these conditions for the patient. As such, Endodontium 1 block functions as a pillar for the subsequent blocks of the curriculum.

Initial level and requirements

The Endodontics 1 block is accessible to students who have received a satisfactory final grade for the blocks 'Integral care: applied prevention 1', 'Diagnostics and planning', 'Restoration 2', 'Function and function recovery 2', 'Communication with and around patients 1'.

Framework plan competencies

I a-1, IVa, VI f,g,i,l,q,s,u

Teaching materials and literature

- Warnsinck CJ et al: Endodontology (4th edition) Bohn, Stafleu, Van Loghum, Houten. 2022
- Blockbook Endodontium 1, 2023-2024
- Additional information, via Documents, on Brightspace

2 Organization of the block

Block coordinator and deputy

Block coordinator:
Drs. D. de Groot - Kuin
Department of Preventive and Curative Dentistry

Examiner and deputy block coordinator: Drs. RHCM van der Horst

Teachers and block committee

Drs. R. van der Horst
Drs. D. de Groot - Kuin
Drs. R Stevens

Teaching methods and study load

Element	Form of education	Contact hours	Self-study hours	Sbu
A	response college	1		1
	self study		4	4
B	response college	1		1
	self study		5	5
C	response college	1		1
	self study		12	12
D	workgroup	1		1
	self study		11	11
AND	workgroup	1		1
	self study		7	4
F	workgroup	1		1
	self study		4	7
G	response college	1		1
	self study		2	2
H	practicum	100		100
'	response college	1		1
	self study		2	2
	practicum	.		.
J	response college	1		1
	self study		2	2
	practicum	.		.
K	examination	2		2
total		111	49	160

Educational facilities

Brightspace, OOC library, endobox and other instruments are available on loan at the pre-clinic counter.

Scheduling: for the updated schedule: see the individual Web file

Endodontium 1 starts in week 36 on Tuesday afternoon and Thursday afternoon, depending on the group to which you are assigned. An introductory lecture will be given on Tuesday in week 36. The work meetings are fixedly scheduled. The practical sessions are mandatory on the day you are assigned and are not accessible if you have not been assigned. This can only be deviated from in consultation with the block coordinator.

Testing and assessment

The cognitive part of Endodontics 1 block ends with an exam. The exam will be administered in writing. This exam may be taken if the result is insufficient

be retaken. A satisfactory final grade for the exam is valid for 1 year.

The preclinical part of Endodontics 1 block is concluded with a final paper. You can start this final project as soon as all previous preclinical procedures have been completed separately with a satisfactory result. All papers count to a greater or lesser extent towards the practical final grade. (See 2.6.3) If less than a 3 was achieved for a preclinical procedure, an additional, similar tooth must be treated as a resit. The test is assessed on the basis of the criteria used in the assessment of preclinical procedures (see 2.6.2). If you fail, you can resit the test a maximum of twice. If the second resit is not completed with a satisfactory result, the student can start the block again at the next intake moment.

All components must be completed separately with a satisfactory result.
You are also responsible for keeping track of your attendance using the assessment form. If you are absent more than three times without a valid reason and/or cancellation, you may be denied access to the block and you may only be given an insufficient final grade.

Preclinical phase: assessment

All specified teeth, both hand-held and set in a jaw, must be provided with a sufficient endodontic opening or root canal treatment. For a tooth for which the procedure and/or result followed would not be clinically admissible, an additional similar tooth must be treated as a resit.

The assessment criteria used are:

Opening phase

A 1 is given if:

- A fausse route/perforation has been created
- The opening is larger than necessary, in a direction not consistent with normal location of has root canal

A 2 is given if:

- The opening, following instructions, is too small, so that the duct wall does not cover the entire surface length can be achieved
- There is a staircase in the course from the pulp chamber to the canal entrance.

A 3 is given if:

- After minimal indications, a clinically acceptable and functionally sufficient result is acquired

A 4 is given if:

- If an opening is made of the correct dimensions, in the correct direction, without a false route/perforation/stairs with a good overview of the channels.

Making the length photo

A 1 is given if:

- The apex of the tooth is not visible on the X-ray
- The length stop does not rest on the reference point when taking the X-ray

• No work has been done under rubber dam

A 2 is given if: • The x-ray
shows significant distortion • Incorrect placement
of the x-ray

A 3 is given if:
• After minimal indications, a clinically acceptable and functionally sufficient result is acquired

A 4 is given if: • A perfect
result is achieved, with no improvement possible

Length determination

A 1 is given if:
• The preparation length is specified with a deviation of 2mm or more from the good length.

A 2 is given if:
• Non-reliable reference points are chosen • The file on
the X-ray appears to protrude 2mm or more through the foramen or remains 4mm or more away from the radiographic apex • More than 2
photos do not meet the criteria mentioned,

A 3 is given if:
• After minimal indications a clinically acceptable and functionally sufficient result is obtained with correct diagnosis and correct reference points

A 4 is given if:
• A result is achieved, where no improvement is possible, with the right one reference points and diagnosis

Preparation

A 1 is given if: • The canal
has been perforated due to an incorrect preparation technique • It has
been prepared more than 1mm too long or too short due to an incorrect length setting • The preparation length is no longer achieved due to an incorrect preparation method • The canal is not clean is • A
file breaks off (and this could have been prevented)

A 2 is given if:
• From the determined main file, 2 or more subsequent files can be adjusted to length are inserted

A 3 is given if:
• After minimal indications, a clinically acceptable and functionally sufficient result is acquired

A 4 is given if:
• A result is achieved where no improvement is possible through correct preparation technique, correct preparation length, correct cleaning and knowledge

To fill

A 1 is given if:

- Incorrect spreaders and/or secondary pins that do not correspond to the channel shape are selected
- Heat carriers/stoppers that are too thick are selected or used for the burn down

A 2 is given if:

- The main pin is too loose for the shape of the canal
- The main pin does not reach the correct length over a distance of 1mm or more

A 3 is given if:

- After minimal indications, a clinically acceptable and functionally sufficient result is acquired

A 4 is given if:

- A result is achieved where no improvement is possible by correct choice of posts and filling technique, whereby the canal is filled to length and presented cleanly.

Final assessment

A 1 is given if:

- The canal appears to have been transported in/over an irresponsible manner/distance
- The root canal filling protrudes more than 1mm through the foramen
- The root canal filling at a distance of more than 1mm from the apical end point of the preparation has ended
- The canal is not homogeneously filled

A 2 is given if:

- Insufficient account has been taken of the development of discolouration caused by filling material. •

Insufficient space has been made for a plastic restoration when it is placed. will become

A 3 is given if:

- After minimal indications, a clinically acceptable and functionally sufficient result is acquired

A 4 is given if:

- A result is achieved where no improvement is possible: the morphology of the element is respected, a homogeneous canal filling is applied, taking into account the development of discolorations and plastic restoration

The criteria described are the most common deviations. Any errors that are not described are at the discretion of the practical management. A professional attitude, preparation and knowledge are also included in the final assessment.

Final grade determination

The final grade is determined by the partial marks for the cognitive test and the weighted average of the assessment of the preclinical procedures. The preclinical procedures are weighted in the ratio

2	Form I (openings in the phantom jaw)
3	Form 2 (abc: with the exception of the perspex blocks, the upper incisor and lower premolar)
5	Form 3(Test)
10	Cognitive Test

3 Learning assignments on the theory of pathology, microbiology and diagnosis of endodontic diseases.

Chapters 1 to 8 and chapters 10 to 16, and chapters 25 to 28 and 30 of the book Endodontology apply to this.

During the first four learning assignments you will focus on disorders of the endodontium and the tissues connected to it.
We start with an inventory of these conditions and the preventive measures to prevent them (LO 1). Subsequently, the diagnosis of pulpal disorders (LO 2) and apical disorders (LO 3) and of disorders that present themselves as endodontics are discussed: differential diagnosis (LO 4). LO 5 and 6 discuss the various endodontic treatments.

Learning assignment 1: Prevention of endodontic diseases

Background

The pulp can become irritated or damaged for various reasons. These causes can be divided into a number of categories. In this learning assignment you will examine what these dangers are for the pulp. Where possible, we discuss how these dangers can be prevented

Partial objectives

You can categorize the etiology of diseases of the endodontium and the tissues connected to it and justify your choice of preventive measures that you can take to prevent these diseases.

Instruction

1. Study chapters 1, 2,10, 26 and 30 of the book Endodontics.
2. Indicate which dangers can threaten the pulp and break them down the following categories: hereditary diseases, acquired diseases, age effects, natural trauma, iatrogenic trauma.
3. Describe how these hazards influence the pulp.
4. What preventive measures can you take to prevent natural trauma and prevent iatrogenic trauma. Consider the method of treatment, use of materials, alternatives.
5. What makes the pulp more fragile than other tissues in the body?
6. Exposure to toxins and antigens from 'the outside world' leads to an immune response in the pulp. Describe all conditions and events mentioned in Chapter 2 in which the mentioned exposure to toxins and antigens may occur.
7. In addition to exposure to toxins and antigens, the pulp can also deteriorate sustain 'injury' in some other way. Describe the conditions in which without there

if there is exposure to 'the outside world', pulp injury resulting in pulpitis or pulp necrosis can still occur.

Products

1. Categorization of etiology of diseases of the endodontium and associated tissues.
2. Justification of preferred preventive measures to prevent pulp disorders

Debriefing

The theory is explained in a lecture. During this lecture, but also during the tutorials, you can discuss the answers to the assignments with your fellow students and the teacher.

Learning assignment 2: Diagnosis of pulp disorders

Background

In learning assignment 3.1 you examined which dangers can threaten the pulp. Learning assignments 3.2 & 3.3 will discuss the disorders of the pulp and associated tissues that can be the result of these threats. After this, you will examine to what extent you can prevent and treat these conditions, in order to prevent the (systemic) spread of these conditions.

Partial objectives

You can diagnose disorders of the endodontium and the tissues connected to it

Instructions

1. Study chapters 1, 3, 16 and 27 from the book Endodontics
2. Describe in your own words the influence of bacteria on the development of pulp disorders
3. Describe in your own words the defense mechanisms in dentin and pulp against these bacterial influences.
4. Describe in your own words the symptoms and effects of the pulp in pulpitis, pulp necrosis, pulp polyp, and internal resorption.
5. Formulate the clinically observable characteristics by which you can determine the condition of the pulp.
6. Describe the tissues of the endodontium: dentin, predentine, odontoblastenlaag, celarme subodontoblastenlaag, celiac zone, central pulp
7. Provide a schematic description of the odontoblast response to a noxious but mild stimulus, such as attrition
8. Provide a schematic description of the pulp response to a noxious, persistent stimulus, such as progressive caries (Note. If the pulp is necrotic, it will no longer respond to the stimulus).
9. Describe the process of internal root resorption. What is the appropriate therapy when internal resorption is observed? When should this therapy take place?
10. Much research has been and is being done into the microbiology of the pulp. For relevant information about the bacteriological status of the endodontium, uncompromising bacteriological sampling of the root canal should take place, which is also aimed at the cultivation of strictly anaerobic bacteria in mixed infections. Provide a summary of the main research results described in Chapter 5.
11. Describe the factors mentioned that cause an infection of the pulp with microorganisms to lead to pulp necrosis and apical periodontitis
12. With exposed tooth necks, there are dentinal tubules that are permanently exposed to the oral environment, i.e. to toxins and antigens. Describe the odontoblast response and the pulp response. How can this exposure be prevented from leading to pulpitis?

13. Describe the theory of dentin sensitivity. The following topics should be discussed: a. the anatomy of a tooth and the endodontic structures b. factors that expose dentinal tubules to the oral environment

    c. the response of the pulp to this exposure
14. Describe the preventive and curative measures that can be taken for sensitive tooth necks
15. On the basis of which observations can the diagnosis of 'sensitive tooth necks' be made? (instead of, for example, 'pulpitis')

Products

1. Answers regarding the influence of bacteria on the development of pulp disorders, defense mechanisms in dentin and pulp.
2. Description of pulp disorders
3. Formulation of clinical features.

Debriefing

The theory is explained in a lecture. Check for yourself whether you can identify criteria for the pulp disorders mentioned that are essential for you, in order to be able to identify the condition of the pulp

Learning assignment 3: Diagnosis of apical periodontitis

Background

As a continuation of 'Learning assignment 2' you now concentrate on the disorders of the tissues that connect to the pulp; more specifically: apical periodontitis.

Partial objectives

You can diagnose disorders of the endodontium and the tissues connected to it

Instructions

1. Study chapters 4 and 5 from the book Endodontics.
2. Describe in your own words the development of apical periodontitis.
3. Apical periodontitis can be accompanied by local effects or symptoms as well as systemic ones. Indicate what these local effects and phenomena are and whether preventive measures are available.
   What can be the systemic effects of apical periodontitis?
4. Formulate the clinical symptoms and features that are important to you for determining the condition of the periradicular tissues.

Products

1. Description of the development of apical periodontitis; description of apical periodontitis and its effects
2. Formulation of clinical symptoms and features that allow you to determine the condition of the periradicular tissue.

Debriefing

The theory is discussed in a lecture. The material will also be discussed in the seminars. Check in the discussion with your fellow students and the teacher whether you have achieved the partial objectives.

Learning assignment 4: Differential diagnosis of apical periodontitis

Background

When diagnosing apical periodontitis, confusion may arise with conditions or symptoms that present themselves as apical periodontitis.
For example, if there is a radiolucency on a lateral root surface, where you clinically notice a pocket.
In this learning assignment you will examine which symptoms and conditions can cause confusion in the diagnosis of apical periodontitis. You will look at which intra-oral and radiological aspects can help you differentiate between the conditions and you will discuss the associated therapies.

Part objective

You can diagnose disorders of the endodontium and the tissues connected to it and indicate the associated therapy

Instructions

1. Study chapters 6, 7, 8 and 25 from the book Endodontics.
2. Indicate which conditions can cause confusion in the diagnosis of apical periodontitis.
3. What diagnostic tools are available to you in differentiating between these conditions and apical periodontitis?
4. Describe the influence of endodontic diseases and endodontic treatments on the periodontium, but also that of periodontal diseases and periodontal treatments on the endodontium.
5. Describe the sequence of treatment and how you assess the treatment result if a tooth is characterized by both an endodontic and a periodontal defect (a so-called 'Pure Combined' Endodontic-Periodontal Problem).

Products

1. Answers to the question about differential diagnosis of apical periodontitis.
2. Answers to the questions regarding the influences of endodontic and periodontal diseases and treatments on each other.
3. Description of diagnosis and treatment of combined endodontic-periodontal disorders.

Debriefing

The theory is explained in a lecture. Check for yourself which diagnostic criteria you have to differentiate between apical periodontitis and conditions that present themselves as such.

Learning assignment 5: Indication for endodontic treatments and CHILDREN score

Background

In the first 4 learning assignments you studied the disorders of the pulp and the tissue connected to it. In learning assignment 3.5 you will determine to what extent you can treat endodontic diseases in order to prevent their (systemic) progression. After the decision has been made to perform endodontic treatment, the degree of difficulty of the treatment must be determined.
The so-called DETI score has been developed for this purpose.

Part objective

You can indicate therapy for diseases of the endodontium and the tissues connected to it and determine the degree of difficulty using the DETI score.

Instructions

1. Study chapters 12, 13 and 14 from the book Endodontology and study the document about the DETI score (found under Documents/ Additional information/Appendix).
2. Indicate what non-surgical endodontic treatment options are available and how they should be performed.
4. Indicate the indication for carrying out these treatment options.
5. Find out what surgical endodontic treatment options are available.
6. Indicate the indication for carrying out these treatment options.
7. To what extent is the use of medications in endodontics indicated or contraindicated?
8. Give at least 5 examples of factors that complicate endodontic treatment.

Products

1. Answers regarding the indication for non-surgical and surgical endodontics.
2. Answer regarding the use of medication in endodontics.

Debriefing

The theory is explained in a lecture. During the discussion with fellow students and the teacher, check for yourself whether you have sufficient insight into which cases you should perform non-surgical endodontic (re)treatment or whether you should switch to endodontic surgery and what the function of medications is. during endodontic treatment.

Learning task 6: Internal whitening of teeth

Background

Popularly, an avital tooth is associated with a dark, gray tooth. However, it does not necessarily have to happen that an endodontically treated tooth becomes discolored. In this learning assignment you will investigate the causes of discolouration of a tooth, how to prevent it and how to treat it.

Part objective

You can indicate the indication for internal teeth whitening and describe how the procedure should be carried out.

Instructions

1. Study Chapter 28 from the book Endodontics
2. Indicate the causes of discoloration of a tooth.
3. Indicate what the treatment options are for these discolorations.
4. Describe in detail the procedure of the so-called Walking Bleach method.
5. Indicate how you would close this element (channel and opening).

Products

1. Answers regarding causes and treatment options for tooth discolouration.
2. Elaboration of the procedure of the Walking Bleach method.

Debriefing

The theory is explained in a lecture. In the discussion with your fellow students and the teacher, you list the indications and methods for internal whitening.

Reader Endodontologie

Theory and background of endodontic treatment

Preface

Root canal treatment can be divided into a number of phases. Each phase serves as preparation for the next. Failure to perform the previous step properly inevitably leads to problems with the next step and can therefore influence the end result of the entire treatment. It is therefore important to have a good insight into the successive steps in the implementation to maximize the chance of success.

In the next series of self-study assignments in this chapter you will study the distinct phases of root canal treatment and investigate their influence on success. This concerns successively:

- endodontic openings (ZSO 4.8)
- coronal preparation and cleaning (ZSO 4.3.4): parts a and b)
- determination of duration (ZSO 4.4.7)
- apical preparation and cleaning (ZSO 4.5.3) and 4.6.9): parts a and b)
- disinfection of the root canal system (ZSO 4.7.1)
- the root canal filling (ZSO 4.8.7)

Parallel to this is the preclinical phase of Endodontics 1 block, where you will apply the knowledge from the self-study assignments to the phantom. The relevant chapters from the book Endodontology apply to this.

Theory 1: The endodontic opening: background and theory

The endodontic opening should provide unobstructed access to the root canals without removing unnecessary tooth material. Naturally, unreliable dental material must be removed (caries), restorations judged to be inadequate must be removed and any cusps must be lowered. All in all, care is taken to ensure that the pulp cavity is opened within a clean and reliable tooth surface, and that the element can be closed as leak-free as possible, if necessary in the meantime and after treatment.

This means that if there is a non-adhesive plastic restoration whose cohesion would disappear through the endodontic opening, it is removed in its entirety, such as with amalgam. However, if this coherence were to be maintained, opening it up through the existing restoration could be considered, which would simplify subsequent restoration. However, the more limited overview can be mentioned as a disadvantage; limited compared to complete removal of the restoration. For this reason, in education it is decided to remove the entire non-adhesive restoration and replace it with an adhesive restoration before continuing the root canal treatment. Subsequent opening of the pulp chamber through the new adhesive restoration makes opening more difficult. Therefore, after removal of the non-adhesive plastic restoration, the pulp chamber is opened and filled with Cavit, before proceeding to fill the preparation with composite, with the aim of facilitating opening in the next session. Naturally, this procedure does not have to be followed if the endodontic treatment is completed in one session; the endodontically treated element can then be completely filled with composite if the root canal has been filled with gutta-percha.

If there is a good adhesive restoration, the endodontic opening can be opened by this restoration, whereby this opening is supplemented with the existing restorative material during treatment.
With cast restorations, the choice will have to be made whether to remove the restoration, preferably intact and reusable in its entirety, or to create the endodontic opening through the restoration. The choice depends on the quality of the restoration. If the restorations function well functionally and aesthetically, there is no secondary caries and the edge connection is good, it will be more likely to be chosen to open through the restoration and thus avoid possible damage to the restoration or the element by trying to remove the restoration. to prevent tapping. If there is a poorly functioning restoration, removal will be more likely to be chosen.

Especially if the cause of the endodontic complaints is leakage due to a poor edge connection or secondary caries, it makes sense to remove the restoration and replace it with a good quality restoration after endodontic treatment.
Removing cast fittings can be done using ultrasonics and a pneumatic or mechanical crown remover. If this proves not to be possible, the cast restoration can be ground off the element to be treated.
The final choice depends on the quality of the cast restoration, when the restoration was placed and of course the wishes of the patient.

The location and design of this endodontic opening should be such that the roof of the pulp chamber can be completely removed, so that an unobstructed view is obtained of the walls of the pulp chamber and their transitions to the pulp floor. Where there is no overview of the entire wall of the pulp chamber and of the transition from a wall to the floor, the material that obstructs this view should be

to be removed. When a complete overview has been achieved, maximum overview of the soil and the root canal entrances present therein is created.
Furthermore, the walls and transitions should be smooth, to facilitate cleaning of the pulp cavity and to reduce the retention of organic material that can cause discoloration. In addition, when opening, the possibility of retention of the (temporary) restoration to be applied subsequently must be taken into account.

1. Requirements Endodontic opening

At the end of the first phase of endodontic treatment, the access made to the pulp chamber must meet the following requirements:

- Good overview of all channels
- Endodontic instruments can be applied without tension
- The element can be easily disinfected and restored, in other words there are no undercuts with pulp remains left and the element can be easily restored
- Not much dental material has been removed unnecessarily. The integrity of the element is maintained and the development grooves remain visible.

2. Procedure

A good initial photo is essential before starting the endodontic opening. The element is visible in its entirety in the initial photo. Opening is initially practiced and performed by using a sharp diamond drill in the high-speed contra-angle with cooling to pierce the element parallel to the longitudinal axis of the element into the pulp chamber.
Start by creating the shape of a 'standard' endodontic opening, only slightly smaller. In advance, the initial photo must be used to estimate the depth of the pulp chamber in the tooth and the extent to which obliteration has occurred. Perforating the pulp roof is felt as a slight overshoot of the drill if you are dealing with a pulp chamber that is *not obliterated*

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is. After this, the remaining part of the roof of the pulp chamber can be safely removed using a “non-end grinding drill” with cooling. The “non-end grinding drill” is a conical diamond drill with a non-grinding point. The latter prevents damage to the bottom of the pulp chamber. Pay particular attention to ensure that the tip of the drill is not damaged and that the tip could be sharpened. In addition, a “non-end grinding drill” will sharpen if you apply hard enough pressure. When preparing with this drill, no pressure should be applied to the apical area.

The opening is ready when the above conditions are met.

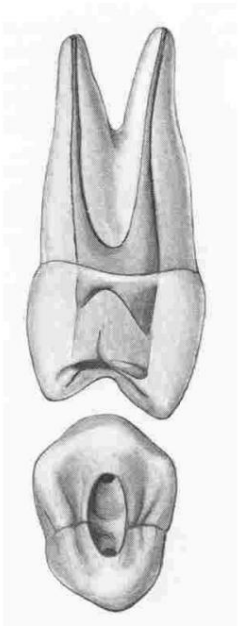
An advantage of opening in the above-mentioned manner is the possibility of quickly opening the pulp cavity of a tooth with minimal pressure. This is especially advisable in cases of severe periapical pain where a slight apical pressure increases the pain even further in intensity.

3. Openings per element type

Upper jaw

In the upper jaw, the presence of a pronounced lingual pulp chamber wall must be taken into account in the anterior teeth. This can obstruct the view of the lingual part of the root canal and therefore prevent proper cleaning. For this reason it must be removed, even though most of the root canal is already visible. This also makes it easier to place the root canal instruments in the root canal. Removal can be done after application of rubber dam with the ProTaper SX.

When opening the upper premolars, one should be suspicious of the presence of extra canals, which can often be deduced from the external dimensions of the tooth (in addition to the information obtained from an X-ray, of course). Furthermore, it often appears that the pulp horns are mistaken for canal entrances. This is because the pointed cusps of these premolars, if used as a reference point, can give a distorted picture of the actual depth of preparation. It is therefore more reliable to use the level of the occlusal surface when assessing the depth of preparation. Furthermore, the pulp floor of upper premolars appears to be located (well) apical to the cementoenamel border. This means that the bottom of the pulp chamber is located very deep in the tooth, which makes it difficult to create a good overview. The pulp horns, on the other hand, are exceptionally visible in a white-yellowish dentin surface.

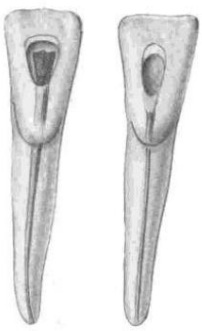


As far as the upper molars are concerned, the mesial wall of the pulp chamber can obscure the view of the second mesiobuccal root canal (the so-called fourth canal or mb2). This should therefore be removed. Since preparation must be carried out down to the bottom of the pulp chamber, constant control must be maintained over the location of the grinding part of the drill. If the back of the corner piece makes the view impossible, you should switch to using small excavation drills on a longer shank; “LN drills” or ultrasonic. The use of these LN drills is an exception and must be discussed with the group teacher.

The search for the MB2 channel is only done when the other channels have been found and a rubber dam has been applied.

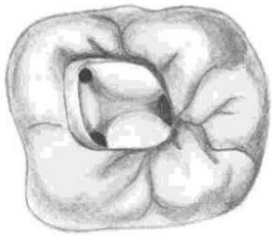
Lower jaw

In the lower incisors and cuspids, the lingual pulp chamber wall must be removed in such a way that an overview of any lingual canal entrance is available. Here too, in exceptional cases, an LN drill can be useful. In this case it may be even more convenient to use ProTaper SX after applying the rubber dam.



As with the upper premolars, additional root canals may be found in the lower premolars, which will modify the shape of the standard endodontic opening.
The small mesio-distal size of the lower incisor means that drills with a smaller diameter are often used.

Lower molars may also have extra root canals; a second distal root canal will necessitate a wider endodontic opening at the site.



Detecting channel entrances

Detecting the canal entrances themselves is best done by inspecting the pulp floor with an ankle refracting mirror and good lighting. The dark development grooves present on the bottom lead, as it were, automatically to the channel entrances at the end. The suspicion about the presence of a canal entrance is supported by probing with a straight probe. This probe should engage in the canal entrance. Due to obliteration or because the canals are at an angle

end up in the pulp chamber, the probe may not engage the canal entrance.
Therefore, always keep looking and thinking carefully.

The so-called tertiary dentin is different in color and structure compared to 'normal' dentin. The darker, sometimes glassy, tertiary dentin can often be distinguished with the naked eye. The extra deposited dentin must be removed in order to make the original pulp chamber walls and floor visible again. This can be done using ultrasound or a drill. A suitable drill for this is the so-called LN drill (Long-Neck) in a green angle piece without cooling. With this drill you can maintain a good overview of the position of the very small drill head. The dentin can be removed in situ with light brushing movements until the development groove is visible again. This drill can also be used if the entrance to the root canal itself unexpectedly turns out to be calcified. It should be paramount that grinding instruments are only used at the bottom of the pulp chamber when maximum overview has been created and when it is clear that extra deposited dentin is being removed.

For this reason, the use of ultrasonic instruments is preferred. Drilling at the bottom of the pulp chamber without being convinced of this is not allowed. The chance of perforating the pulp base is extremely high!
These final adjustments to the endodontic opening are best done after rubber dam has been applied. The use of magnification (microscope) is a very good tool.

An additional aid in case of uncertainty regarding the location of channel entrances can be the use of transmitted light. By darkening the working area as much as possible, and then x-raying the tooth with a sharp point light source (for example as used in caries diagnosis, or the composite curing lamp), the dentin will light up except where it is interrupted by canal entrances (or a fracture). : these will appear as dark (shadow) points. The use of an X-ray is also recommended when a clear search for canal entrances is required. By fixing the last used drill (for example with wax) and using it to take an x-ray that is as horizontal as possible, a good picture is created of the relationship between drill head and canal entrance; This is even more the case when two x-rays shot at a different horizontal angle are used.

Extra tips

-Knowledge of the anatomy of an element and surrounding structures is essential.

-When opening a tooth, pay attention to the axis direction, the mass of the crown relative to the root and in the lower jaw for crown flight.
-Before opening, draw a cross on the crown exactly above the root.
-Regularly check the direction of insertion of the drill.
-No endodontic opening without a good diagnosis.
-Keep in mind the purpose of an endodontic opening: to create an overview and space for preparation, restoration and chemical cleaning.

Theory 2: Rubber dam

The root canal treatment will usually be performed in an (extensively) restored tooth. This restoration (more: the influence of microleakage) will have influenced the size of the pulp cavity over time, in the sense that the deposition of tertiary dentin will have changed its shape compared to a young tooth. In addition to the already described disappearance of the original occlusal anatomy and information about the axis direction, this is the reason to wait until the canal entrances have been located before applying a rubber dam. This is to maximize overview and minimize the risk of incorrect routes or perforations. When working with instruments in the canals, such as files, the element must always be under a rubber dam.

Draining

After locating the canal entrances, the element to be treated is drained using a rubber dam. This creates a clean and orderly working area, greatly reducing the possibility of bacterial contamination of the root canal.
Rubberdam offers excellent protection to the patient for aspirating or swallowing instruments, materials and flushing agents. It ultimately leads to a faster and calmer treatment method. Where the grip for the rubber dam clamp initially appears insufficient, recourse can be had to the use of special clamps (A-clamps: sharper and deeper gripping jaws), or additional retention can be provided by applying GIC or composite around the points of application of the clamp on the element. The "slit dam" technique can also be used, in which an incision is made in the rubber dam and the clamps are placed on the neighboring elements over the incised rubber dam. Sometimes it is advisable to use the distal neighboring element for fixation of the rubber dam clamp, for example when the element to be treated will be provided with a multi-surface restoration in the same session, or to have more space for indirect vision.

In the event of minor leakage between the tooth and the rubber dam, this can be stopped by applying a layer of liquid rubber dam (Fastdam) to this transition. The liquid rubber dam is applied from the syringe and hardened using the composite lamp. Applying Cavit is also an option.

Initial cleaning

After applying the rubber dam, the resulting working area is disinfected using a cotton ball soaked in alcohol. The tooth, clamp and rubber dam are successively moistened using a cotton plug dipped in alcohol.

The inside of the tooth (the endodontic opening) is rinsed with sodium hypochlorite (NaOCl – 2.5%, pH 12) using a 12cc syringe and a 20mm long, 27 gauge needle (ISO 35-40).

Theory 3: Root canal preparation, coronal phase

After locating the canal entrances and draining the working area, the entrance to the root canals is widened. After this, dentin is removed from the root canal walls from coronal towards apical; a path is made apically into the root canal: the step-down phase. The advantage of this compared to immediately inserting an endodontic file at depth without step-down is many. 1.

First of all, the entrance to the root canal becomes clear: any (partially) obliterated canal entrance will become clearly visible and accessible. 2.

Furthermore, the NaOCl will have a long time to work in the coronal part of the root canal; where most bacteria will be found. A reservoir of NaOCl is created in the pulp chamber and canal entrance; Every time an instrument is inserted further into the root canal, it will carry with it an amount of NaOCl. This means that dry preparation is not performed during root canal treatment, because the canal is full of NaOCl during preparation!

3. In addition, the chance of squeezing infected canal contents through the apical constriction will be reduced. This has a favorable effect on the occurrence of subsequent objections. Continuous insertion of instruments beyond the previous preparation level results in a smooth root canal wall. 4.

And by creating "working space" in the coronal part of the root canal, the cleaning of the apical part is simplified: the NaOCl will be able to reach the apical part more easily and in larger quantities. 5.

The root canal is 'straightened' in the coronal part, which provides more control over the tip of the endodontic files. This is because the apical part of the file is the only active part that will jam against the root canal walls.

Coronal preparation with mechanically driven NiTi instruments

A step-down approach is chosen for canal preparation. The canal is prepared from coronal to apical with various instruments that increase in thickness, creating space for cleaning with NaOCl. Before the
canal entrances and the upper part of the canal are made wider, it must first be checked whether the canal is accessible with a file 8 and a file 10. Then the entrance and the upper part of the canal are opened with a so-called SX (a mechanically driven NiTi instrument). the canal dilated. The SX is used in a corner piece that is connected to the endomotor. The setting used is 300 rpm and a torque of 2 to 5.2 Ncm. The setting is pre-programmed in the endomotor.

Protaper SX

The rotating instruments are placed in the canal while rotating; After a maximum of 5 seconds or 3 'picks', the instrument is removed from the canal, the patency is checked with a file 8 (recapitulate) and flushed again. In the coronal phase it is wise to proceed a little further with the hand file to ensure that no debris is clogging the canal.

The purpose of the coronal phase is to dilate the entrance to the canal and the upper 1/3 of the canal so that it can be cleaned with NaOCl.

Theory 4: Werklengtebepaling

The working length indicates the distance from a chosen occlusal reference point to the most apical part of the root canal that will be cleaned. Correct determination of the working length is essential. The aim is to have the working length end just before the apical constriction of the root canal. The apical constriction forms a natural narrowing of the root canal, and is therefore an anatomical and histological site favorable for the mechanical blockage of the filling material.

Preparing too far or too short significantly increases the risk of long-term clinical failure of the root canal treatment.

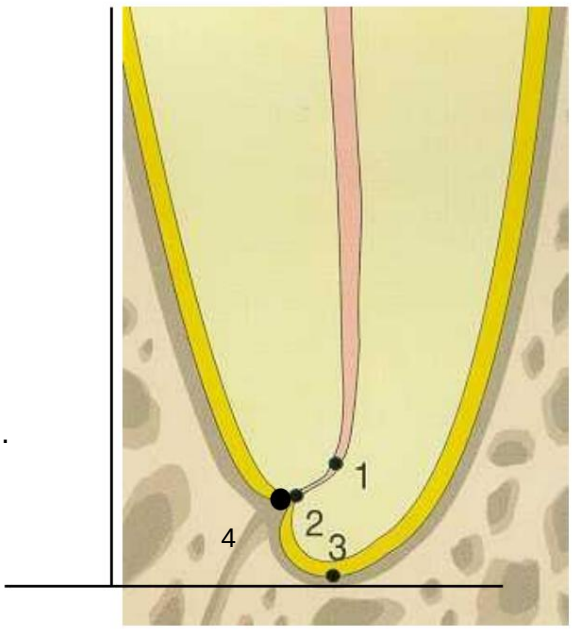
The apical constriction is located just in front of the apical foramen. The apical foramen is often located eccentrically and is therefore not located on the radiological apex. On a radiological basis, the apical constriction would be located in a zone varying between 1 and 2 mm from the radiographic apex.
Excessive preparation lengths should be avoided in order to:

- prevent damage to the peri-apical tissue;
- prevent extrusion of flushing fluid or filling material;
- prevent transport of infected tissue into the peri-apical zone;
- to guarantee good condensation of gutta-percha against the root canal walls with the undamaged apical constriction as a natural barrier.

Too short a preparation length should be avoided in order to prevent the persistence of infection of the root canal.

To clarify:

1. Apical curvature
2. Apical constriction (this is the narrowest point and is close to the apical foramen)
3. Anatomical apex/radiographic apex
4. Apical foramen (the opening at the end of the tooth root where the pulp tissue merges into the periodontal tissue).



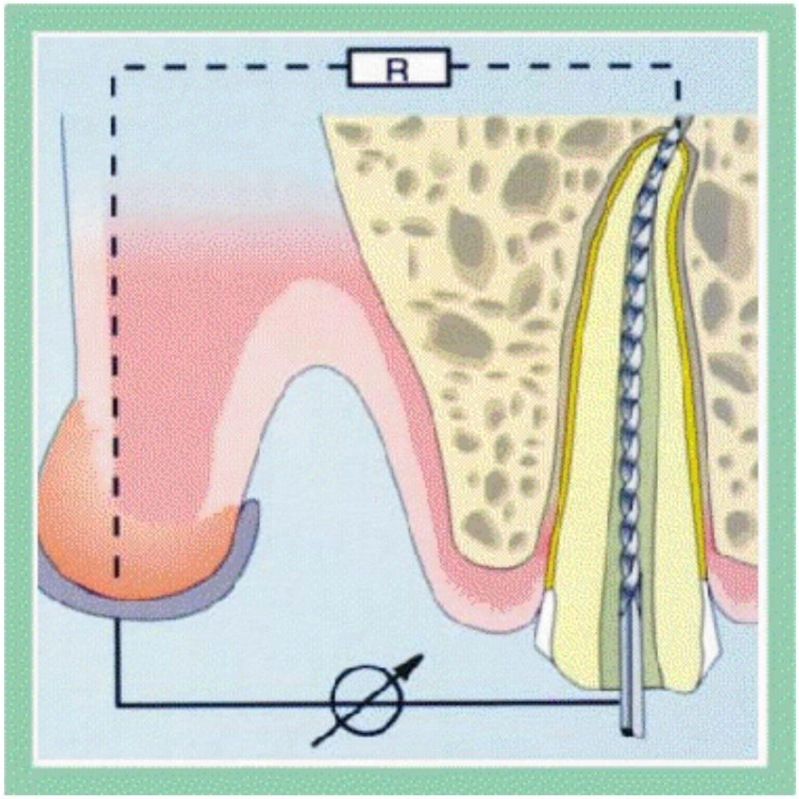
Techniques for determining working length

What we see on the X-ray is the radiographic apex or the root tip. As mentioned earlier, in many cases the anatomical apex (the apical foramen) does not correspond to the radiographic apex, as we see it on the X-ray, because the apical foramen or the apical constriction are covered with dentin they will not be seen on the X-ray become.

The most commonly used technique for determining the working length is electronic length determination, which is verified radiologically.
In endodontics, X-rays are necessary for diagnostic purposes.
However, radiographic length determination does not appear to be highly accurate for determining working length because it is based on a two-dimensional image of a three-dimensional root canal system that is subject to intra- and inter-individual variables when interpreted. An X-ray does not provide us with information about the root curvature in the bucco-lingual or bucco-palatal direction, nor about the precise location of the constriction and the apical foramen.
Furthermore, there are also the limitations associated with the distortion of radiological images.
It is therefore not possible for us to accurately determine the location of the apical constriction, because it is not visible on the X-ray.
In addition, there are difficulties in interpreting the images, which are due to superposition of different anatomical structures.
Furthermore, there are also interpretation errors related to the resolution quality of classical or digitalized radiographs.
However, an X-ray remains indispensable as it is the only diagnostic tool that allows visualization of the root system. However, precise localization of certain microstructures, such as the apical constriction, remains impossible with this method.

Measuring principles of the electronic length determiner

A thin Kerr file connected to the electronic length finder is inserted into the canal. A weak current passes from the file electrode via the root canal to the mucosa electrode. The moisture or fluid in the root canal serves as a conductor for the electrical current into the peri-apical zone. Even though the tooth root or dentin insulates the electrical current, the resistance in the root canal remains constant. At the apical constriction the root canal cross-section becomes narrower and the electrical resistance therefore reaches its maximum.
At this point the current is lowest. Pushing the file past the constriction widens the cross-section of the canal, reduces resistance, and increases electrical current. When the foramen is reached, the current spreads in all directions because there is no more insulating dentin. The resistance of the electrodes is strong in the root canal and remains constant until constriction is achieved. This reaches its maximum at the apical constriction. When the file is pushed further, the resistance suddenly decreases. At the apex the current spreads in all directions without any resistance.
The distinction between the apical foramen and the apical constriction is often hardly different and can hardly be determined histologically. The measuring equipment is often very accurate, but the human variable is not. The length indicated by the electronic length determiner is therefore shortened by 1 mm.



With the electronic length determiner you are able to:

- to perform particularly accurate length determinations during endodontic treatments;
- accurately identify any abrupt curvature of the most apical part of the canal to establish. By using a file 08 or 10 to determine the length, you can see at the tip of the file after determining the length whether there is an abrupt curvature of the last millimeters of the canal. The tip of the file will remain in the same shape if there is an abrupt curvature, which is important with rotating NiTi;
- determine perforations: in the event of a perforation, the length determiner responds as if you were measuring the measuring file through the apex. You can also determine perforations caused by, for example, internal resorption with your length determiner. As soon as the file is introduced into the resorption defect, the meter will read as if you were inserting the file through the apex.

Apex Locator user manual: Root ZX

During this procedure, rubber dam should be applied as usual. The root canal wall should be moist from the NaOCl used. With a multi-canal tooth, there may be no contact with the other canals via the NaOCl; the excess NaOCl will then first have to be removed. This is also necessary for large conductive restorations

the excess NaOCl in the pulp chamber can be removed. Contact of the file with metal restorations should be avoided, as this may result in an incorrect length determination.
The presence of root canal filling materials, large lateral canals and an unformed apex can also cause problems with this form of length determination.
With multiple channels, measure 1 channel at a time and do not leave files in the other channels.

1. The Apex Locator is turned on by pressing the MAIN button on top of it device;

2. Check the lighting display to see whether the batteries are still sufficiently charged (top right corner: BATT)

3. Hang the cheek hook on the patient's lip; the mucosa must be moist to ensure conduction;

4. Attach the file holder to the shaft of the file to be used; make sure that the rubber length stop of the file is on the "apical" side of the file holder;

5. Insert the file thus connected into the root canal to be measured and move the file towards the apical direction; the display shows this apical movement with an ascending dashed bar;

6. When the apical part of the canal is reached, this is shown in the display by a flashing dash bar; an acoustic signal is also given. From this point only a small distance (approx. 0.5 mm) to the apical foramen should have to be bridged;

7. Therefore, very carefully move the file a little apically until the word APEX appears in the display and the Apex Locator emits a continuous warning tone. The position of the apical foramen would now have been determined;

8. To obtain a reproducible point (the foramen), slowly repeat the up and down motion of the file until the point where the Apex Locator sounds the single warning tone again. As soon as you hear the tone, stop the downward motion and hold the file in place.

9. While the device remains switched on, the rubber length stop of the file is pushed against the reference point;

10. Now the file can be removed from the root canal and the length measured. It device turns off;

11. To determine the working length up to the apical constriction, (0.5) -1 mm of the measured file length subtracted;

12. Where possible, the file length thus achieved is also assessed radiologically with a longitudinal photograph.

13. Inform the patient about what you are going to do.

Advantages and disadvantages of electronic length determination.

Advantages of apex locators:

Immediate measurement result, thus saving time.

Detection and localization of the apical foramen.

Effective localization independent of the solutions in the channel (youngest generation).

Accurate and reproducible measurements (youngest generation).

Accurate height determination is also possible in pregnant women due to reduced exposure to ionizing radiation.

Disadvantages of apex locators:

Do not use in patients with a pacemaker. (According to the manufacturer's manual.)

Possible error measurement in case of an open apex.

(Text taken from 'electronic length determination ProPex made in collaboration with Prof. Jean-Pierre van Nieuwenhuysen (Université Catholique de Louvain) and dentist Joerd van der Meer.)

The electronically determined working length is verified with an X-ray; After the working length has been determined electronically, a length photo is taken with files in the root canals that are set to the electronically determined working length.
When an electronic height determination is not feasible, such as in a preclinical setting, only radiographic length determination is used. Since the apical constriction is not visible on the X-ray, a point is used at 1 to 1.5 mm from the X-ray apex as the end point of the root canal preparation, based on anatomical data. The distance from this point to the occlusal reference point is the working length. This reference point must be reliable, which means that it must have a fixed position throughout the entire treatment (i.e. no filling or weak lump), and that the file (in this case the rubber stop that indicates the working length on the file) is without bending or voltage is in contact with that point. This means that the reference point is usually chosen at the corresponding canal, i.e. when the length of the mesio-buccal canal is determined, the mesio-buccal cusp is chosen as the reference point. If this is not possible because the file deflects too far, more dentin above the entrance to the mesio-buccal canal must be removed until the file is tension-free in the canal and the matching cusp can be chosen as a reference point.

Length photo instruction

The (provisional) working length can be estimated based on the initial photo. Place this initial photo on the computer screen and press the button with “calibrate”. Place the cursor at the location of the suspected reference point and click the left mouse button. It is now possible to draw a line on the screen that runs across the canal to the apex. Double click when the cursor is on the radiographic apex. (While drawing, it is possible to make the line follow a curve by clicking once on the left mouse button where such a curve begins.) You will now see “calculated distance” in the window.

a preliminary value of the length of the element. The preliminary working length is this value minus 2 mm. Please note, however, that this value does not take into account any distortion that may have occurred in the photo. (An obliquely shot photo of an upper molar often shows a long palatal radix and very short buccal radices.) The provisional working length is therefore determined by the measured value on the photo with clinical findings in the patient (large or small teeth) and combine average values. The preliminary working length is set on a file. This is done by positioning the rubber stop at the correct length on the shaft of the file. The canal is then made accessible at this length with a file 8 and a file 10 and a glide path is then prepared with the Goldglider. This is also a mechanically driven NiTi instrument. The motor setting must be set to “Wave one”.

A photo is then taken with a file in the canal(s), the so-called longitudinal photo.
The end point of this file should be clearly visible on the x-ray. For this reason, the thickest file that can be inserted into the root canal at the set length is used, and this file must be at least ISO no. 15. Furthermore, for reliability in measuring distances, the file used should be secured in the root canal at the desired length.

With a multi-canal tooth, overprojection on the X-ray could cause confusion when naming the individual canals. To prevent this, different types of files are used in those channels that could cause confusion: K-files and H-files (see below). Each file should preferably make contact with the reference point at the set length (the rubber stop).

In Digora are noted:

- element number,
- which channel contains which type of file (H-file or K-file),
- the set file length,
- the reference point
- the working length as determined from the photo

This notation should be used as standard. This is so that we can act adequately in the event of any follow-up treatment.

b.v: Element 36

MB rö V20=18,0 mm refpnt: MB kn top ML rö	WL: 19 mm
Vh25=18,5 mm refpnt: ML kn top D rö V40=21 mm	WL: 18,5 mm
refpnt: distale randlijst	WL: 21,5 mm

MB	=mesiobuccal canal
ML	=mesiolingual canal
D	=distal canal

rue	=the set length of the file at the time the x-ray was taken
Hv	=heat current delay
refpnt	=reference point
WL	=werklengte

The agreement is that a hedström file is always placed in the most lingual or palatal canal. If there is a good reason for this, this can be deviated from, as long as it is properly noted in the journal.

The length determination photo can then be taken in the X-ray booth.
The X-ray film should be placed as parallel as possible to the longitudinal axis of the tooth. To determine the final working length, it is important that both the apex of the element and the occlusal stops on the files are properly depicted in the photo. In the clinical situation, the green aiming aids intended for this purpose are used for the longitudinal photo. Make sure that the film holder is placed correctly and is properly supported on the neighboring elements. Sometimes it is not possible to work with sighting aids. The bisector control technique is then used in which the film is fixed by the patient's finger or with the help of a needle guide.

If the first length photo is not successful because essential information is missing, always ask the teacher to assist with the second attempt.
In order to be able to make statements about multi-canal teeth, and to assess whether additional root canals may be present, the film will have to be exposed from a horizontal angle (approx. 200). With front teeth and molars this is done distally, and with premolars from mesially. When interpreting the X-ray, the following applies:

is exposed mesially, the lingual part of the element will also be depicted more mesially than the buccal; and when illuminating from Distal, the Lingual part will be imaged more towards Distal. The final working length is determined by comparing the length of the file with the length of the root on the length photo.

In the clinical situation the length is determined electronically. If there is a large discrepancy between what has been determined electronically and what can be seen on the photo, the electronic length determination is carried out again. The electronic length determination is decisive when determining the final working length.

If electronic length determination is not possible (as is the case in the phantom setting), the working length is estimated based on the photo. The basic principle here is that the canal must be prepared and cleaned up to the apical constriction. Research has shown that the apical constriction is 1 to 1.5 mm from the radiographic apex. On Phantom, the final working length is determined in consultation with the teacher.

If major adjustments need to be made, a new length photo may be taken to check the new lengths.

It is wise to properly document the length determination. The following is noted for this:

- ÿ element number
- ÿ which channel contains which type of file (H-file or K-file).
- ÿ the actual (also called the radiographic) length of the file
- ÿ the reference point
- ÿ the calculated working length
- ÿ angle of entry (if different from the normal angle)

When the working length has been determined, a clear, unambiguous note of the working length determination is made in the journal:

b.v: Element 36	
MB VLF Kv20=18,0 mm refpnt: MB kn top ML VLF	WL: 19 mm
Hv25=18,5 mm refpnt: ML kn top D VLF V40=21 mm	WL: 18,5 mm
refpnt: distale randlijst	WL: 21,5 mm

MB	=mesiobuccal canal
VLF	= photo file length (the actual length of the file at the time the X-ray was taken was created)
Hv	= heath current
ref punt	= reference point
WL	= the determined, final working length

Theory 5: Root canal preparation with nickel titanium mechanically driven instruments

The use of nickel titanium mechanically driven instruments

Since the time when the root canal system had to be enlarged with instruments in order to be able to clean it chemically, there has been a need to make this design easy. Due to the use of instruments made of relatively stiff stainless steel, you sometimes see problems arise, such as channel wall deviations and transport of the channel, so-called strip perforation, zip transport and ledges. When the first endodontic files made of Nickel-Titanium (NiTi) appeared on the market at the end of the 1980s, a material seemed to have been found that could possibly also be used mechanically driven.

Properties of Nickel Titanium

Nickel titanium (NiTi) was developed in the early 1960s by WE Buehler at the Naval Ordnance Laboratory for the United States space program. The material turned out to have super-elastic properties. This means that the material can bend further (without breaking) than would be assumed based on the metal lattice. In addition, the material turned out to have a “shape memory”, which means that the material wants to return to its original shape after deformation. Due to these special properties, NiTi is a metal that is more elastic and less susceptible to breakage than stainless steel. However, it is also less hard than stainless steel. As a result, the cutting capacity of NiTi files will decrease more quickly than stainless steel files. Both nickel titanium hand files and rotary files have been developed.

The purpose of using NiTi instruments

With proper use of nickel titanium instruments it is possible to respect the anatomy of the root canal better than with stainless steel instruments. There is less damage and blockages in the canal. This allows the channels to be cleaned as optimally as possible. Once again: the cleaning of the root canal system does not take place by removing dentin in the root canal, but by chemical disinfection.
This requires frequent rinsing with sodium hypochlorite from the start of treatment. The hypochlorite disinfects the root canal system and dissolves remaining pulp tissue.
Tissue that is not removed (debris) can serve as a breeding ground for bacteria and prevents proper three-dimensional filling of the canal system. For proper disinfection and complete dissolution of the tissue, the NaOCl needs time to work and must be changed regularly. For example, for complete dissolution of pulp tissue, regular renewal of a sodium hypochlorite solution (2.5%) is necessary for about two hours.

Nickel titanium as mechanically driven instruments

It was already mentioned that nickel titanium is less hard than stainless steel. This means that the cutting capacity of the files will decrease sooner. Working with nickel titanium hand instruments is therefore time-consuming. Due to their flexibility and shape memory, nickel titanium instruments are not only good as hand instruments, but they also prove to be excellent for use in a rotating movement. This allows the root canal to be efficiently prepared with less effort for hands and fingers, without endangering the anatomy of the root canal.
There are many different systems on the market. Some examples are: Light Speed (that's where it all started), Protaper and Wave-one from Maillefer, K3 from Sybron

Endo, Hero from Micro Mega, Reciprov from VDW, etc. Research shows that the systems do not show any significant difference in the final result. Wave-One from Maillefer was chosen for education. (In previous years the Sytem GT-X from the same company was used).

Shape: Tapered

The term “taper” or conicity is used to indicate the increase in diameter of the active part of the instrument. For (hand) files, the diameter of the instrument is indicated in hundredths of a millimeter at 1 millimeter from the point, according to ANSI/ADA standards: the so-called D1 value. A file "30" is then 0.3 mm at 1 mm from the point. The increase in instrument diameter is 2% for most hand files. Because such conicity of a preparation is not sufficient for filling a root canal, in manual preparation the conicity of the preparation is increased by performing a step-back preparation, as will be described later. With most NiTi systems, the required channel shape is achieved by giving the instruments a greater conicity or “taper” of, for example, 4% or 6%. We therefore speak of a taper .04, taper .06, etc. This can sometimes be recognized on the instruments by the number of rings, namely 2 rings = taper .04 or 4% increase in diameter at 1 mm from the tip.

Figure 1: coding of the different tapers of the old System GT files, the color coding indicates the thickness of the file according to ISO standards

Preventing breakage

A frequently heard objection to rotary NiTi instruments is instrument breakage: a fragment of a file remains in the root canal during preparation. The broken fragment is very difficult or impossible to remove and where the canal is obstructed by the broken instrument, shaping and cleaning is no longer possible. The vulnerability of the instruments has decreased considerably because the instruments are made from increasingly better alloys. With current instruments, the risk of breakage is a lot less than it was, but caution and careful use are still required. If there is an infected pulp cavity at the level and apical of the broken instrument, the prognosis of the treatment becomes poor. It is therefore very important to prevent instrument breakage.

Basically, two types of breakage can occur in instruments.

1. Due to **metal fatigue.** This causes small hairline cracks in the metal grid due to use. Ultimately, these cracks weaken the lattice so that the instrument will break. The risk of fracture due to metal fatigue increases the more often an instrument is used. NiTi instruments are used in the clinical situation

used only once (on one element) and then thrown away. On the one hand due to the occurrence of metal fatigue and the decrease in cutting capacity, and on the other hand in the context of infection prevention.

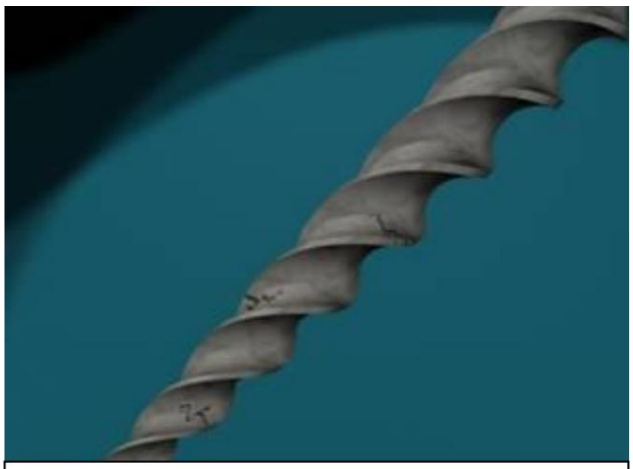


Fig. 41: as an instrument is used more often, more and more micro-cracks will appear in it.

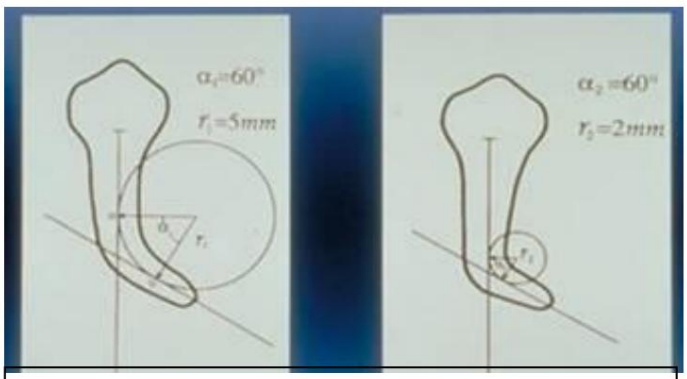


Fig 42: It is not so much the curvature of a root canal as the radius of the curvature that is important for the load on a NiTi instrument.

The risk of fracture due to metal fatigue not only increases with the number of times an instrument is used; The chance of fracture also increases as the canals being prepared are more curved, especially if the radius of the curvature is small.

If there is a combination of such a strong, rapidly occurring curvature and a thin canal with many calcifications, the glide path will have to be kept clear (recapitulation) and prepared extra carefully.

Sudden curvature also occurs at places where two canals meet. An example of this is the mesial canals of the lower first molar or the mesiobuccal canals of the upper first molar. Often these channels unite to form a channel in the apical one-third of radix. By inserting hand files into both canals, it can be checked whether there is a convergence of the canals.

If only one of the files can be brought to the original working length, there is there is fusion of the channels. If curvature occurs suddenly, that part of the canal can only be prepared with hand instruments. The use of NiTi instruments will almost certainly result in fracture in the apical region.

2. Breakage also occurs as a result of torsion forces. This causes the tip of the instrument to become stuck while the rest of the instrument continues to rotate. Ultimately, the tip of the instrument tears off when the forces are too great. In most cases, this type of breakage can be prevented by working neatly according to the manufacturer's guidelines. It is important that a sliding path for the instruments is indeed cleared and kept clear using hand files and rinsing with NaOCl. Furthermore, the windings of the instruments must be kept clean in between to keep the cutting properties of the instrument optimal. In addition, it is used

of electronically controlled motors and contra-angle handpieces with a slipping clutch that ensure that the forces on the instruments do not exceed preset values. This is the most advanced form of torque control. A rotation speed and force setting (torque value) recommended by the manufacturer have been entered for each instrument. If the force on the instrument becomes too great, the direction of rotation of the motor reverses for a few rotations, causing the instrument to unscrew from the root canal. Furthermore, the properties of the files have been greatly improved by conditioning the files, shaping the cutting surface and direction of the cutting surface.

In addition, there are systems (including the Wave-one that we use here) in which the file rotates alternately counterclockwise and clockwise. The so-called reciprocal movement.

From the point of view of the aesthetics of the preparation form and the speed of preparation, the use of mechanically driven NiTi instruments is certainly recommended. However, hand instruments retain their place in endodontics and will always have to be used for the initial preparation, to create a glide path and in cases where the anatomy of the canal or iatrogenic damage makes the canal inaccessible with a mechanically driven instrument. .

Working with NiTi instruments

The opening

Although NiTi instruments are very elastic, the strong bending of the material leads to the build-up of stresses. That is why it is even more important to create a good endodontic opening when using these instruments than when using stainless steel hand instruments. The opening of the element should be arranged in such a way that the instruments can be introduced straight into the canal entrances without tension, which will minimize stress on the material and reduce the risk of breakage. In English literature, this is referred to as *“straightline access”.*

The straight access is achieved by using the non-end grinding diamond drill.

Application of rubber dam

After achieving the correct opening, the tooth is placed under a rubber dam and the pulp chamber is rinsed with sodium hypochlorite. The pulp chamber remains filled with continuously refreshed sodium hypochlorite throughout the procedure. The rubber dam procedure is assumed to be known and has already been discussed in Chapter 4.2.

Figure 2 Canal shape before and after preparation

Figure 3 Cleaning of the root canal with NaOCl

Creating a glide path and coronal widening
After the element has been provided with a good opening, the channels must be made further accessible for the NiTi instruments. To this end, the length is estimated on the initial photo. Check accessibility with a file 8 and a file 10. The access to the root canal is then widened with the SX. This is a mechanically driven NiTi instrument.

By cleaning the pulp chamber and the upper part of the canal, a very large part of the infected pulp tissue has been removed.

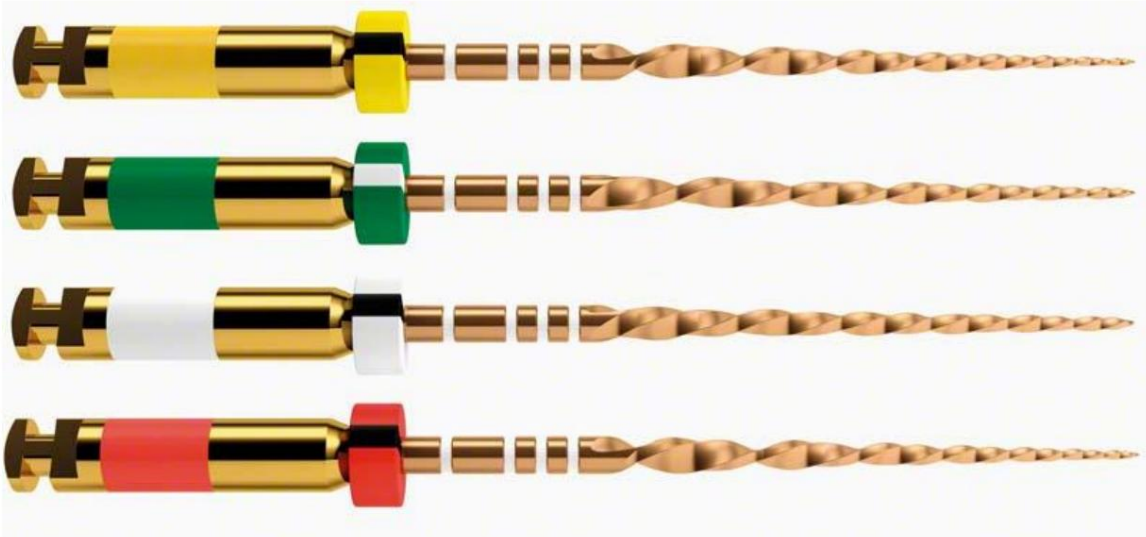
SX

Apical phase, rotating nickel titanium instrumentation
After the length has been determined electronically (chapter 4.4), the initial preparation is again carried out with hand files with file 8 and file 10 working length. The canal is then made further accessible up to working length with a Goldglider (also a mechanically driven NiTi instrument).

Goldglider

After preparation with the Goldglider, the length photo is taken with a 15 file at working length in the canal(s).
This allows the working length to be checked radiologically, but the canal course (curvatures) can also be seen and whether any canals may have been overlooked.

After the length photo has been taken and the final preparation lengths have been determined, the canals are prepared in their final shape with the Wave-One instruments.
Wave-One Gold uses 4 different files, namely 20/.07, 25/.07, file 35/.06 and file 45.05. The slash(/) number represents the apical diameter of the instrument 1 mm from the tip (D1). The number after the slash is the taper. The taper of these files is therefore 7%, 6% and 5% respectively.
However, in education we *do not* use this first file 20/.07, because to check and make accessible the canals, one has already prepared with hand file 20 and this file therefore has no extra added value and these thin instruments are slightly more sensitive for breakage.



Wave One Gold

Method

- After the endodontic opening, coronal preparation and determination of the working length, the rotating instruments are adjusted to the working length.
- The glide path has already been prepared with hand files 8 and 10 and the Goldglider and a longitudinal photo taken with a 15 hand file in the canal.
- Start with the 25/.07 file (primary). Some canals will be so wide that even with a 25 file the working length is achieved without removing much dentin.
  When the working length is reached without much reduction, you can move on to the next file in the system.
- The coronal part of the canal is prepared with the first file of the system: the file with the (25/.07 taper). The instrument does not remove dentin for more than a few seconds (3-5) each time. When the file no longer moves apically with light pressure, it is removed and inspected. The windings are cleaned if they are filled with debris.
- With a file 10 or 15, the sliding path is cleared to the working length. After this, rinse with NaOCl.

- The canal is prepared again with the same file until the working length is reached. Again, the file is used in the root canal for only 3-5 seconds.
- This sequence is repeated until the final file is 25/.07 (primary). prepared to length. The step-down principle allows for deeper preparation the second time than the first time.
- Once the working length has been reached with the file, the preparation can be done with the 35- series (35/.06: medium) are performed in exactly the same way.
- Canal preparation is complete when the canal is prepared to working length with 35/.06 (medium).

Theory 6: Hand instruments and the balanced force technique

Handinstrumentarium

There are two types of files: the K-file (K for Kerr) and the H-file (H for Hedstrøm). The K-files are available in stainless steel and nickel-titanium versions; they can be supplied for hand use and machine use. The H files are made of stainless steel. The K files have a rounded point; This is because a sharp point could drill into the bend of a root canal and find its own way. Since 1958, files have been standardized (ISO standard), so that there is reasonable uniformity between the products of different manufacturers. For example, the working part of a standard file is 16mm long, with an increase of 0.2mm in corresponding diameter per millimeter of length (conicity = 0.2. However, new files are being produced with conicities from 0.4 to 1.2). Each successive file has a fixed increase in diameter, measured 1mm from the point (however, intermediate sizes are also available from some manufacturers). This diameter also gives the number ("the name") to the file: for example, file no. 15 has a diameter of 0.15mm at 1mm from the point. Furthermore, the order of subsequent files is linked to a color coding on the handle (see table 1). Files are available in lengths of 21mm, 25mm, 28mm and 31mm (and from some manufacturers also in different lengths).

Table 1: Coding and sequence of files according to ISO standard

Color	gray	purple	white	yellow	red	blue	green	black
	08	10	15	20	25	30	35	40
			45	50	55	60	70	80
			90	100	110	120	130	140

The material of the hand instruments used in education is stainless steel. These files are particularly suitable for the preparation technique used in education, the “balanced force” preparation.

As for the file itself, the root canals are prepared with K-files, as they have a lower risk of breakage than H-files: a K-file is made by twisting a triangular, square or diamond-shaped bar, while an H- file is made by milling out a round rod. H-files are used to distinguish between the different canals when used together with K-files in the length determination photo, and when removing loose materials from the root canal (pulp cord, gutta-percha, paste, cotton balls) when the file is of sufficient thickness (at least no. 25) and is loosely placed in the root canal.

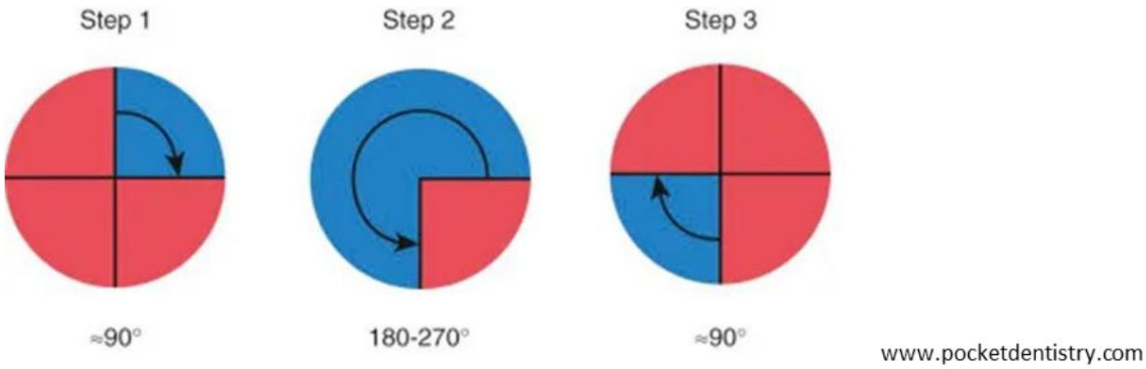
The position of the rubber stop on the active part of the file should also be checked consistently during filing.

The condition of the file must also be continuously inspected: as soon as the file is bent, or windings are twisted, or a shiny facet is visible, or a piece has broken off, it should be thrown away in the needle box and to be replaced with a new one.

Balanced Force technique

Preparation with hand instruments may be necessary early in treatment if a canal is obliterated or if a curvature is present. The method used for this is the balanced force method, as originally described by Roane et al. To this end, as soon as the file touches the root canal walls, it is turned a quarter turn clockwise into the root canal with a rotating movement. This causes the file to become stuck in the root canal. In order to remove the dentin that has been "grabbed" by the windings of the file, the file is turned three-quarters of a turn counterclockwise, applying so much apical pressure to the handle of the file that it is not rotated out of the root canal during this counterclockwise rotation. but remains in place. By turning back with counter pressure, dentin is “cut off”. This dentin is also transported coronally by the windings in the file, which reduces the chance of apical blockage. This procedure is repeated without removing the file from the root canal until the apical preparation length is reached. (This must be done with feeling.

If it feels “heavy” it is wise to remove the file earlier, rinse it and perform the procedure again with a thinner file). The file is then removed from the root canal and is pulled up along a root canal wall during removal. Pulling the file up along different walls is especially important when cleaning an oval canal. The root canal is then rinsed thoroughly with NaOCl: at least 2cc, until the aspirated fluid is clean. This must be done after every file used in the root canal! The file itself is reset to the clean position every time you use it. The clean stand is a reservoir of sodium hypochlorite covered by a sponge into which the files can be inserted.



Theory 7: Disinfection

After preparation, the pulp cavity still contains remains of necrotic tissue, debris and bacteria. These are located on the canal wall and in the dentinal tubules. Therefore, the pulp cavity must be rinsed clean with a disinfectant. The ideal disinfectant should have the following properties:

- Has a broad antimicrobial spectrum and high effectiveness against anaerobic and facultative anaerobic microorganisms
- Dissolves organic pulp residues
- Inactivates endotoxins
- Prevents the formation of a smear layer during instrumentation and removes the smear layer
- Is safe to use

NaOCl dissolves tissue and has an excellent disinfectant effect, although it must be replaced regularly. NaOCl loses its effectiveness upon contact with organic material. This means that after each instrument that has prepared the pulp cavity, this space is rinsed with 2cc NaOCl or more, if the emerging fluid still contains visible abrasions or contaminants. This escaping NaOCl is extracted as close to the element as possible with a mist extractor.

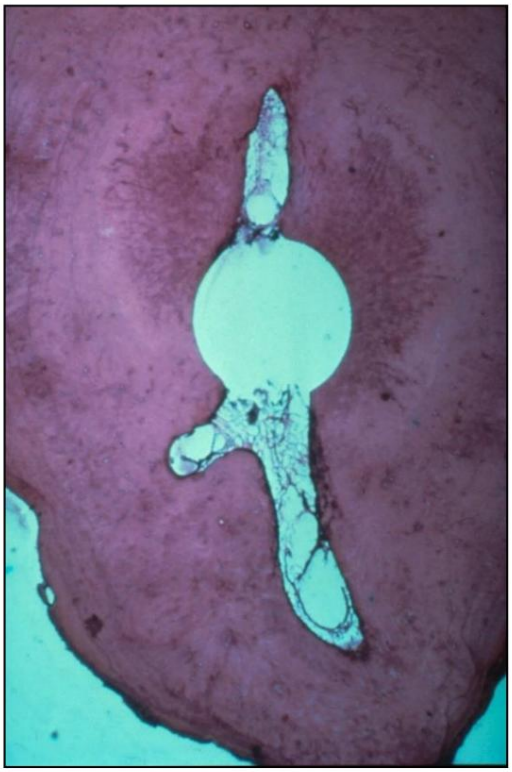
The needle through which the NaOCl is injected into the pulp cavity must never get stuck in the root canal. This is because rinsing creates such a great pressure on the liquid column of NaOCl that there is a good chance that it will be pressed through the apical constriction.
This leads to immediate swelling and severe pain in the patient. This, fortunately reversible, process is so serious that it must be prevented at all times. That is why the needle must sit loosely in the canal, so that the fluid has the opportunity to flow out of the root canal coronally along the needle. These reactions cannot be a reason not to use NaOCl: if done correctly, the complication described above is not necessary

to act (which has been demonstrated over many years of use, including in education); It has been established that NaOCl provides good cleaning, and the product also appears to be safe with superficial contact with tissue (such as the apical periodontium), so that it can also be used in an apexification procedure. As long as it is not pressed into the tissues under pressure.


Figure 1: Make sure the needle never gets stuck like that!

Further properties of NaOCl are its haemostatic effect and its bleaching character.
The latter also means that one must be extremely careful when using it: spilling on clothing leaves irreparable bleach stains.
It should be realized that the NaOCl applied through a needle into the root canal actually reaches the canal up to 1 mm before the end of the needle.
If the needle can only be placed in the entrance, no fluid will be replaced at the apical level and no chemical cleaning will take place here. It is therefore important that the canal is designed in such a way that the flushing needle can be placed in the canal up to 1 mm before the working length.

The complex anatomy of the pulp cavity means that large parts of the canal system remain uncleaned with rinsing alone. Recent research shows that adding ultrasound induces microcurrents in the irrigation fluid, which results in better removal of debris from the canal system. Adding ultrasound is done by placing an ultrasonically vibrating file in the prepared root canal filled with fresh NaOCl for 20 seconds. The procedure is repeated 3 times to obtain optimal results. The use of ultrasound is introduced in education during the test and in the subsequent Endodontium 2 block.



Theory 8: Filling the root canal and medications

Cold lateral condensation of gutta-percha

When filling the root canal, the aim is to close the connection between the oral cavity and the periradicular periodontium as hermetically as possible. To this end, the prepared and cleaned root canal is filled three-dimensionally with a well-sealing and stable filling material. Since accessory canals towards the periodontium can originate at any level along the root canal wall, the root canal is in principle filled over the entire prepared length. However, if it is known that immediately following the root canal treatment part of the root canal will be occupied by a root post as a retention site for a structure to be applied, this can be taken into account during the filling phase by partially filling the canal (see below: this part is not practiced in Endodontium 1).

The filling material used is gutta-percha in combination with a root canal sealer (Top Seal). This material meets the described conditions, is biologically very tolerant, has proven clinically good service over many years of use, is visible on X-ray due to radiopacity, and is reasonably cheap. Furthermore, if necessary, this material can be safely removed from the root canal; This would be the case, for example, if a root post had to be placed or a re-treatment had to be carried out. This material can be processed in and outside the root canal in various ways, such that it can be adapted to the root canal wall; the presence of a (slowly hardening) root canal sealer is necessary.

Cold lateral condensation of gutta-percha was chosen as the filling method for preclinical education. This is an almost universally applicable method that has proven clinical value, is fairly easy to learn, and is relatively time-consuming.
The basis of this filling method is to hermetically close the root canal from apical to coronal by inserting standardized gutta-percha pins and sealer, and condensing them towards the root canal walls (laterally). This is done by pressing the inserted gutta-percha against the canal wall with a special instrument, the spreader, after which a subsequent gutta-percha post can be placed in the resulting space.

Cold lateral condensation procedure

A gutta-percha post is fitted into the prepared and cleaned root canal that corresponds as closely as possible to the shape and diameter of the apical part of the prepared canal. This is called the main pin. Using tweezers, a gutta-percha pin is inserted into the root canal that corresponds in diameter to the apical diameter. This post is pre-dipped in NaOCl or alcohol to clean it before it is introduced into the canal. If the root canal is still moist, it makes it easier to fit the gutta-percha post. The correspondence in shape and diameter with the apical part of the root canal is checked by carefully removing the gutta-percha pin from the canal with tweezers. A slight resistance should be felt. If this resistance is not felt, either use a larger size post or carefully remove a piece of the apical part of the post with a scalpel. After this, the fitting is repeated. Furthermore, some pressure is also applied to the main pin to assess whether it cannot be inserted further than the working length; If this were the case, either the post is too thin or the preparation length is incorrect. In addition, the gutta-percha pin must be able to be inserted to its full length. This is checked by grasping the pin with tweezers from the reference point and relating the length to the working length of the main file. This length is recorded on the gutta-percha pin by pressing the gutta-percha pin at the point with the jaws of the tweezers; The dent always provides insight into the position of the post in the root canal during filling.

When fitting, the trade-off arises between selecting a post that can be inserted to the full working length, but then has no retention when removed, or one that has little retention.

has in the root canal, but cannot be inserted to its full length, then the choice is for a post that can still be inserted to its full length. The 'remaining' space is then filled with cement and secondary posts (see below).
The approved head pin is placed aside on sterile gauze.

Furthermore, a number of thinner gutta-percha posts, the secondary posts, are required, which will be used to fill the part of the root canal remaining next to the main post. In order to properly insert these posts into the root canal, space is created with the spreader. A spreader is a smooth metal rod with a rounded tip, and with the same conicity as endodontic files. The length of spreaders is also the same as that of the files. They are available in 4 diameters, of which the thinnest (A) and the thickest (D) are not suitable for the intended application. There are finger spreaders and hand spreaders. Due to the greater risk of excessive force development with hand spreaders, finger spreaders will be used in education.

Table 2: Spreaders and corresponding secondary pins

Spreader	Colour	ISO countries	Secondary pin
B	Red	25	20
C	Blue	30	25

Since the spreader makes room for the secondary pin to be subsequently inserted, the diameter of that pin must be linked to that of the spreader. However, the accuracy in the production process is greater with metal instruments than with gutta-percha pins. This may mean that despite the same ISO coding, a gutta-percha pin has a larger diameter than the corresponding spreader. This is the reason to choose secondary pins 1 size thinner than the diameter of the spreader as secondary pins to be used for each size spreader.
Furthermore, the preparation method leads to the creation of a channel that continuously tapers from coronal to apical: a funnel shape. If this form also requires good apical condensation, thin instruments and materials will have to be used.
That is why spreader B is used as standard when condensing (and therefore as secondary pins no. 20). A number of secondary posts no. 20 are placed on a sterile gauze pad next to the main post, after being cleaned with NaOCl or alcohol.
The root canal sealer Top Seal is then created. This is a slow-setting sealer on a synthetic resin basis (epoxy resin). Equal lengths of paste are brought together from both tubes on the mixing block and these pastes are mixed until an even yellowish color.

The root canal is now completely dried with paper markers, these are also available in ISO sizes and can be inserted into the canal with tweezers at working length; checking is done by passing the last paper marker over the rubber dam. A dry duct will not leave a trace of moisture. After this, the main post can be cemented into the canal.
To this end, the post is coated with root canal sealer and pushed lengthwise into the canal using tweezers (notch of post at reference point).
A spreader B set to the working length is then slid into the channel next to the main pin; the spreader should push the main pin away laterally through the applied pressure. This sliding in of the spreader is done with a rotating movement and vertical pressure. In principle, the spreader should be able to be inserted up to the level of the first step-back file; This can be checked by the distance from the rubber stop to the reference point. The spreader is left in this position while a secondary pin at working length is grasped with tweezers and the bottom 4 to 5 mm is pulled through the Top Seal. The spreader is now removed from the root canal
with a rotating movement, after which the secondary post is immediately inserted into the created space

is being pushed back. This should not take time, otherwise there is a chance that the laterally condensed gutta-percha will bounce back, causing the secondary post to not move into place. It is therefore recommended to remove the spreader from the channel with one hand and place the secondary pin with the other. The spreader is removed with a rotating movement to prevent the gutta-percha pin from being pulled out of the canal due to the friction against the spreader (check by notching in relation to the reference point).

After inserting the first secondary pin, the spreader is rotated back into the canal under pressure; the level at which it can be inserted will now be less deep than when inserted for the first time. The spreader is left in this position, and in the meantime the second secondary post is grasped lengthwise in the tweezers and coated with root canal sealer. This secondary pin is placed immediately after removing the spreader.

These actions are repeated until the entire root canal is filled. In those cases where at a certain level during filling the spreader can always be inserted at the same depth as with previous secondary posts, this is a sign that the root canal has become wider at that location.

In the case of a multi-canal tooth, the main posts of two canals located in the same radix (e.g. 2 canals in the mesial radix of a lower molar) are placed simultaneously, after which both canals can be filled alternately by means of cold lateral condensation. This method prevents secondary posts from being accidentally introduced into the root canal that is not being filled. Sealer is also pressed into the system of side channels between the main channels.

For the same reason, for multi-channel elements where the channels are not very close to each other (and therefore there is no need to fill several channels simultaneously), filling is started from the channel that is most easily accessible. After removing the excess after filling, we then proceed to the channel that is best accessible, etc.

Single Cone

A gutta-percha post is fitted into the prepared and cleaned root canal that matches the shape and diameter of the prepared canal as closely as possible. The single cone filling technique is based on the idea that the last used file and the matching single cone have a good match so that the canal is completely filled.
In practice, however, it often appears that the canal is oval after preparation in the buccolingal direction and not round like the gutta percha post. A single cone gutta percha post will then fit better in the mesiodistal direction than in the buccolingual direction. For this reason it is always important to fit the post before cementing the post. Filling with a single cone is more dependent on the cement used due to the discrepancy between the gutta percha pin and the prepared canal. The duct should be well coated with cement.

The single cone technique cannot be used in every channel. For naturally oval canals (single-canal lower incisors, single-canal upper premolars, single-canal distal roots of lower molars, palatal canal of an upper molar), lateral condensation remains a better technique for filling the canals.

Procedure Single Cone

Using tweezers, a gutta-percha post is inserted into the root canal that corresponds to the last file used (WaveOne 35.06). This post is pre-dipped in NaOCl or alcohol to clean it before it is introduced into the canal. If the root canal is still moist, it makes it easier to fit the gutta-percha post. The correspondence in shape and diameter with the apical part of the root canal is checked by carefully removing the gutta-percha pin from the canal with tweezers. A slight resistance should be felt. If this resistance is not felt, a piece of the gutta percha post is cut off apically.

Apply sealer to the canal using a lentulo spiral in the endomotor on Protaper SX mode. Place the single cone until it reaches the desired length.

Finishing of duct filling

The excess gutta-percha protruding from the canal is removed with a hot PKT.
To this end, it is held in the gas flame until the instrument glows, after which the excess gutta-percha can be melted off in one go with a sweeping movement. The remaining gutta-percha mass is then condensed vertically. This is to compensate for the cooling shrinkage and to use the plasticity of the gutta-percha created by the heat to adapt it (even better) to the wall. This condensation is done with hand stoppers. These are straight metal rods with a flattened end with which the gutta-percha can be put under vertical pressure. These instruments are always used in a cold state. They are available in various ISO sizes; In education we use stoppers specially made for KUN in sizes 30&40, 50&60 and 75&90. A stopper is used that covers the gutta-percha as much as possible without making contact with the root canal wall. A thinner stopper would puncture the gutta-percha more than condense it; a thicker stopper could generate too much pressure against the wall (with the risk of introducing fractures).

At the clinic, the excess gutta percha is removed using an ultrasonically vibrating round ETBD tip from the UG cassette with the PS Newtron on position 8. By placing this tip on the canal entrance and activating it, frictional heat is generated, which separates the excess gutta percha. of the final canal filling.
The gutta-percha smeared on the bottom of the pulp chamber can be removed with heat and hand or rotary excavators, after which the pulp chamber can be washed with alcohol-soaked cotton balls to remove excess sealer. Ultimately, the floor of the pulp chamber should be completely free of gutta-percha and root canal sealer.

Preparation for a root post

If a root post is to be placed immediately following the root canal treatment, it is wise to take this into account now by leaving the required length in the root canal free of gutta-percha. Since gutta-percha provides a better seal for the root canal than a root post, gutta-percha should not be unnecessarily removed when making room for a root post. Preferably, one should know the length over which the root canal will be filled with the root post, so that the gutta-percha can be applied up to that level. In any case, it must be possible to achieve as much gutta-percha length as possible, in order to provide the best possible closure of the root canal (coronally and accessory canals). The minimum length for a sufficient seal is 4mm gutta-percha. A shorter length can no longer guarantee sufficient closure, which makes the result of installing time-consuming and expensive restorative facilities uncertain

The way in which the desired space can be freed is by filling the root canal with lateral condensation until the moment is reached at which the rubber stopper of the spreader is at the same distance above the reference point as the length over which the canal must be filled. The excess (non-condensed) gutta-percha located coronal to this level is then removed. This can be done with heat.
A so-called heat carrier is used for this purpose. This is a pointed instrument that is made red-hot in the gas flame. Due to the material composition and shape of the PKT wax-up instruments, they are very suitable to function as a heat carrier.
The red-hot instrument is then inserted into the excess gutta-percha, moving the tip of the heat carrier into that gutta-percha mass.
While this instrument is cooling, the gutta-percha will stick to it. If necessary

this can be repeated several times. The gutta-percha filling remaining in the canal is then condensed vertically using a suitable stopper.
Another more predictable method is the ability to remove excess gutta-percha is by using a Gates sliding drill. The thickest size is used that can be introduced into the canal at the end point of the filling level. In the green corner piece without cooling, this Gates sliding drill, with a stop of the correct length, is placed in the gutta-percha mass, after which vertical pressure is applied at full speed. The friction will cause the gutta-percha to become warm and therefore soft, which is noticeable because the Gates "beats" its way through the gutta-percha. By moving the Gates up along the walls, the gutta-percha will be transported out of the element as balls. Subsequently, the remaining gutta-percha filling is also vertically condensed. It is preferable to place the pin afterwards.

If this happens in a subsequent session, the element is closed with a temporary filling of Cavit and GIC (see temporary restoration procedure).

Medications: temporary restoration

During root canal treatment, the aim is to start and complete the treatment in one session where possible and desired. This is because it appears that this can limit the occurrence of after-effects, because it ultimately takes less time, because it is more pleasant for the patient, and because it can have a positive influence on the healing process. However, there are situations in which a root canal cannot be filled: lack of time, persistent fluid drainage, and the desire to include a medication in certain periapical conditions.
In these situations the channels are rinsed well with NaOCl and then
the element is coronally sealed with a temporary restoration to prevent the risk of reinfection between treatment sessions.
Until recently, the root canal was filled between two treatment sessions with a long-acting disinfectant: a paste of Ca(OH)2. However, research has shown that the added value of this is very limited. It also appears that it is difficult to completely remove the Ca(OH)2 and that it can negatively influence the adaptation of the final canal filling to the canal walls.

Procedure: Temporary restoration

In principle, a double seal is used for the temporary restoration: this is to prevent the risk of leakage as much as possible. A 3mm thick layer of Cavit is applied to the canal entrance and bottom of the pulp chamber. This material only hardens under the influence of moisture. Application is done by applying a ball of Cavit into the opening with a PFI 6 and pressing and pressing it towards the bottom of the pulp chamber with a wet cotton ball in tweezers. The excess of Cavit against the walls of the pulp chamber is removed with a straight probe or excavator.

A sturdier restorative material is then applied to this first layer of Cavit. For simple restorations (= endodontic opening in a still firm occlusal surface) the choice is glass ionomer cements, for example.
For very large restorations, where cusps and margins need to be supplemented and strengthened, a composite restoration is applied after the Cavit underlay.
During a crown preparation, the well-fitting emergency crown is cemented back in or the crown that has just been removed is adjusted and temporarily replaced if possible.
NB: In the exceptional situation of an endodontic opening in an otherwise intact clinical crown, where the temporary restoration cannot handle occlusal loading

will receive, it is sufficient to fill the entire endodontic opening with Cavit if the follow-up treatment will take place within two weeks.

Self-study assignment 1: (Th 1): Endodontic openings

The first self-study assignment will focus on the endodontic opening of teeth, as the first practical step of root canal treatment after indication.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Draw the location and shape of the standard endodontic opening for each tooth on the occlusal surface, indicating the location of the root canal entrances.
3. Indicate the expected number for each tooth root canals are, and what possible variations are possible found that are important for endodontic opening.
4. Describe in your own words the changes that a tooth and the pulp undergo over time and to what extent this influences the creation of the endodontic opening.
5. Write a step-by-step protocol for manufacturing the endodontic opening. This should include:
    - The opening photo
    - rotation / inclination van het te openen element
    - existing restorations
    - caries
    - anatomy of the element
6. anatomy of the pulp chamber: where is the pulp roof located, where is it located? the pulp chamber floor?

Products

1. Answer on the influence of age changes on the performance of root canal treatment
2. Drawings of endodontic opening shapes indicating numbers of root canals and any important variations thereof

Debriefing

The products are explained in a seminar, together with the findings of the associated preclinical practical

Self-study assignment 2: (Th 3): Coronal preparation and cleaning

Background

The third self-study assignment focuses on making the root canal accessible for endodontic instruments and materials. In order to be able to properly introduce instruments and especially flushing fluid into the canal system, it is important to make the canals accessible.

Two techniques are described below:

- the step down phase associated with manual root canal preparation
- preparing the coronal part of the root canal as part of the root canal preparation with rotating instruments.

This phase begins after the teeth have been opened and is used to determine the length of the root in question.

Part objective

You can describe the various methods available to make the root canal accessible and argue for specific advantages and disadvantages of these methods.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Indicate the advantages of the step-down phase.
3. Describe the step-down procedure step by step.
4. Indicate alternatives for using the Gates sliding drill.
5. Write a step-by-step protocol for fabricating the coronal preparation. This should include:
   - The curve of the square root
   - Estimation of the working length and determination of the 'coronal phase' werklengte'
   - Rubberdam
   - Hand instruments to be used (file 10-15-20)
   - Mechanically driven instruments to be used

Products

1. Description of step-down procedure, including alternatives for instrument use

Debriefing

Debriefing takes place in the form of a seminar. Check for yourself the relevance of coronal preparation and cleaning before inserting instruments apically into the root canal.

Self-study assignment 3: (Th 4): Determination of length

Background

After making the root canal accessible and thus cleaning the coronal part, the final preparation length must be determined. To determine where the preparation should end, one must have knowledge of the anatomy of the apex. Determining the preparation length, also called working length, is done using an electronic length gauge and X-rays.

After determining the working length, apical cleaning can take place.

Part objective

You can indicate where the apical preparation should end, you know how this end point of the preparation is determined and why.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Indicate where ideally the apical preparation ends and explain why
3. Indicate the shortcomings of radiological length determination.
4. Write a step-by-step protocol for performing the electronic length determination. This should include:
    - Sodium hypochlorite
    - Patency of the foramen
    - File to use (thickness, length)
    - Result of the height meter
    - Determining and recording the working length
    - Verification with an X-ray
    - Factors that hinder length determination with an electronic length gauge

5. Why is no electronic height determination performed in the preclinical phase? What is the disadvantage of determining length using an X-ray?

Debriefing

Debriefing takes place in the work and hearing lectures. Find out for yourself why the working length determination only takes place after the coronal preparation.

Self-study assignment 4: (Th 5): Apical preparation and cleaning with hand instruments

Background

After determining the working length, the next phase of root canal treatment consists of apical preparation and cleaning. There are basically 3 methods available for manual preparation: reaming, filing and balanced force. In this tutorial assignment, you will explore what these methods entail and examine the pros and cons of these methods in order to select the optimal method.

Goal

You know the three most important methods for apically preparing a canal and can argue which method you prefer based on the advantages and disadvantages of these methods.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Write down the advantages and disadvantages of the three methods respectively. Please indicate which method you would suggest to prepare the apical part of the root canal. Indicate which specific part or parts were decisive for you.

3. What are the conditions that the root canal preparation must meet? and what are these conditions based on.

Products

1. Categorization of preparation methods with advantages and disadvantages and indicating personal preference.
2. Answer to the question regarding the conditions of a root canal preparation.

Debriefing

Discussion takes place in the tutorials and lectures. In the discussion with your fellow students and the teacher, determine what the most optimal preparation method is.

Self-study assignment 5: (Th 6): Apical preparation and cleaning with rotating instruments

Background

The preparation of the root canal can be performed not only with hand instruments, but also with nickel titanium mechanically driven instruments. This preparation method is taught as a standard technique. In this self-study assignment you will learn how the method differs from preparation with hand instruments. Attention is also paid to the properties of nickel titanium.

Goal

You know the idea behind the use of mechanically driven nickel titanium instruments for preparing the root canal. You know the greater taper principle and the associated preparation procedure. You know the advantages and limitations of using mechanically driven instruments.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Describe the positive and negative properties of nickel titanium.
3. Indicate the differences between hand-held instruments and mechanically driven (nickel titanium) instruments. Consider properties such as flexibility, design, preparation technique.
4. Describe the procedure associated with root canal preparation and cleaning with mechanically driven instruments
5. The standard preparation technique is preparation using system Wave One (Gold), mechanically driven instruments. List the duct treatments that should not be performed with rotating nickel titanium. Describe the technique to be used in these cases.

Products

1. Answers to the questions

Debriefing

The subject is discussed in the tutorials and lectures.

Self-study assignment 6: (Th 7): Disinfection of the root canal system

Background

The self-study assignments on opening the tooth, making the root canal accessible, and apical preparation were mainly mechanically oriented. In self-study assignment A.2 you delved into the relevance of the presence of bacteria for the development of endodontic diseases. It is not possible to remove this infection from the root canal mechanically. This will require the support of disinfectants.

It is stated that this is also the most important part of the entire root canal treatment: making the root canal accessible and preparing it primarily serves to enable the disinfectant to reach and disinfect the entire root canal.

A multitude of agents can be used for this disinfection. In this self-study assignment you will examine which groups of resources could be used for this purpose, and what the specific advantages and disadvantages are associated with these resources. Ways to improve the effectiveness of these resources are also discussed. The importance of keeping the root canal disinfected between two treatment sessions is discussed when you consider how the tooth thus treated can be temporarily sealed coronally.

Instructions

1. Study the applicable chapters and Brightspace documents.
2. Make a list of root canal disinfectants, organized by group main active substance; indicate how adequate the disinfection is and what the advantages and disadvantages of these products are.
3. Indicate what options are available to improve the disinfection of the root canal.
4. Indicate how a tooth in which endodontic treatment is being performed should be temporarily sealed coronally.
   Take into account the condition of the root canals and the shape/size/extension of the existing endodontic opening.

Products

Categorization of root canal disinfectants with indication of advantages and disadvantages of these agents. Indicating possibilities for improving root canal disinfection. Answer to the question of how a tooth should be temporarily sealed between two endodontic treatment sessions.

Debriefing

The subject is discussed in the tutorials and lectures. Determine for yourself what the role of intracanal medications is in endodontics and determine your own preference for a drug or drugs.

Self-study assignment 7: (Th 8) Root canal filling

Background

After cleaning the root canal, the next step is filling it. This is to prevent reinfection and to prevent irritation of the apical periodontium. Various materials and techniques have been described for this part of the root canal treatment.

Medications are used as a temporary filling method. In the past, silver was frequently used as a permanent filling method, in combination with cement. Only cement was also used. Today, the filling material of choice is gutta-percha which is condensed with a sealer in the cleaned and shaped root canal.

In this self-study assignment you will explore the reason for choosing gutta-percha and how it can be processed. You choose your optimal method, justify this choice and describe the method.

Goal

You can describe the various filling methods that exist and justify your choice for the optimal filling method based on the advantages and disadvantages of these methods.

Instructions

1. Study the applicable chapters and Brightspace documents
2. Indicate the advantages and disadvantages of the filling materials and methods used in the past compared to those with gutta-percha and sealer
   Determine what the optimal method of filling with gutta-percha would be for you, justify this choice and describe the procedure

Products

1. Categorization of root canal filling materials with specific advantages and disadvantages
2. Argumentation of the ideal gutta-percha filling method with explanation of technique

Debriefing

Discussion takes place in the tutorials and lectures. Justify for yourself the choice of gutta-percha and the preferred method of processing it.

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