METHODS OF ROOT CANAL WORKING LENGTH DETERMINATION

Minsk BSMU 2021

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
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МЕТОДЫ ОПРЕДЕЛЕНИЯ РАБОЧЕЙ ДЛИНЫ КОРНЕВОГО КАНАЛА

METHODS OF ROOT CANAL WORKING LENGTH DETERMINATION

Учебно-методическое пособие

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На английском языке

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INTRODUCTION

One of the leading places in the structure of dental diseases (35–39 %) are complications of caries — pulpitis and apical periodontitis [Leus, 2014]. Complicated dental caries is an emergency medical problem. It includes a complex polyetiological nature of diseases and the absence of a unified approach to their therapy. In practical dentistry, at present, the results of endodontic treatment of complicated forms of caries cannot be considered satisfactory [J. J. Segura-Egea, 2013; W. H. Qian, 2015; T. N. Manak, 2016; N. T. Bainozarova, 2017].

HISTORY

End of 19th century: WL was calculated when file was placed in canal & patient experienced pain

1899: Kells introduced X-rays in dentistry.

1929: Collidge studied the anatomy of root apex in relation to treatment problems.

1955: Kuttler microscopically studied the microscopic anatomy of root tip, and decided that filling to the radiographic apex was an unwise clinical procedure, contributing to postoperative pain.

1969: This year significantly contributed to evolution of electronic apex locators.

The system of main canals in one root, the functional unit of the tooth is represented by numerous morphological variants primarily due to the number and location of root canals.

Seltzer et al. were the first to report greater success in terminating cleaning & obturating the root canal system just short of the radiographic apex rather than overfilling or underfilling. Jorgen et al. reported the best outcome was when the canal filling was between 0–2 mm short of radiographic apex.

According to Cohen and Burns, 1mm of a canal with a diameter of 0.25 mm, which is the diameter of narrower foramens, provides enough space to lodge nearly 80,000 streptococci, so filling should be found at the apex. Chugal found variations in success rates of root filled at different levels:

Normal preoperative pulp & periodontal tissues are filled over 1 mm from radiographic apex.

Necrotic pulp & apical periodontitis means that the canal filling is closer to radiographic apex.

DEFINITIONS

A root canal is the naturally occurring anatomic space within the root of a tooth.

The pulp is the part in the center of a tooth made up of living connective tissue and cells called odontoblasts. The pulp is part of the dentin-pulp complex (endodontium).

Endodontics (from the Greek roots endo- "inside" and odont- "tooth") is the dental specialty concerned with the study and treatment of the dental pulp.

ANATOMY

Pulp space in the root canal system is presented. It includes a core, canal body in the center of the root throughout its duration, and additional short branches separated from it at different levels of the pulp and periodontium. Communication is carried out not only through the backbone canals, but additionally (accessory) canals (Fig. 1, 2). They are also called lateral because they are arranged at right angles to the main canal. Often, they are defined in the root furcation.

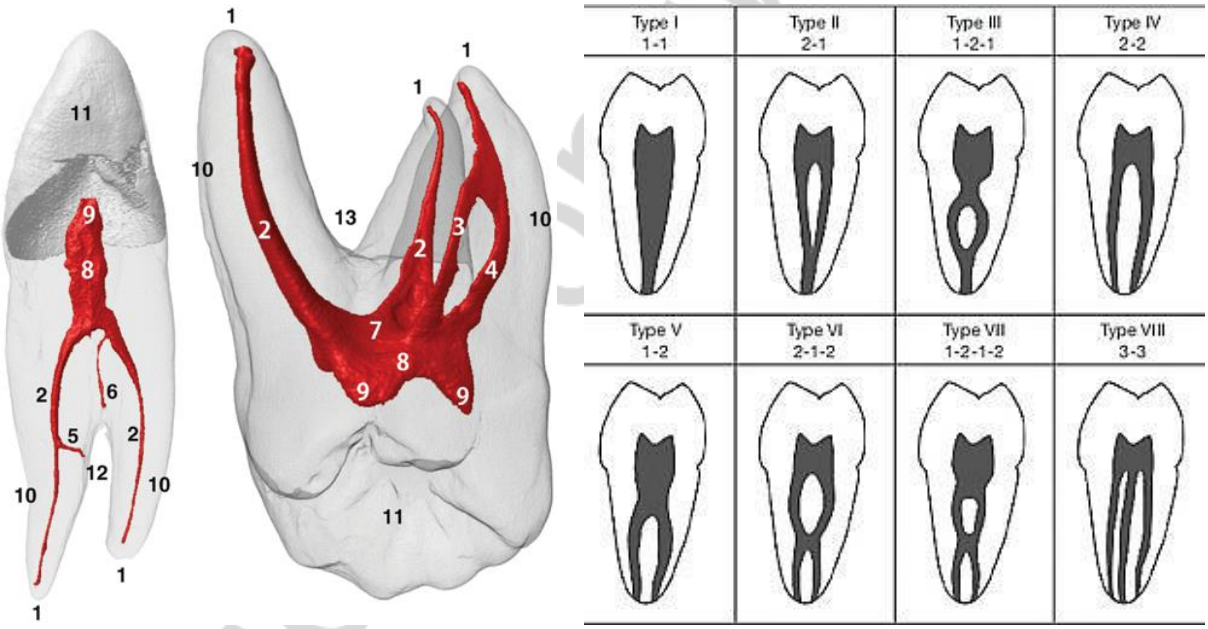

Figure 1. Additionally (accessory) canals:
1 — anatomic apex; *2* — root canal; *3* — MB2 canal; *4* — MB1 canal; *5* — lateral canal; *6* — furcation canal; *7* — pulp chamber floor; *8* — pulp chamber; *9* — pulp horn; *10* — root; *11* — crown; *12* — bifurcation; *13* — trifurcation

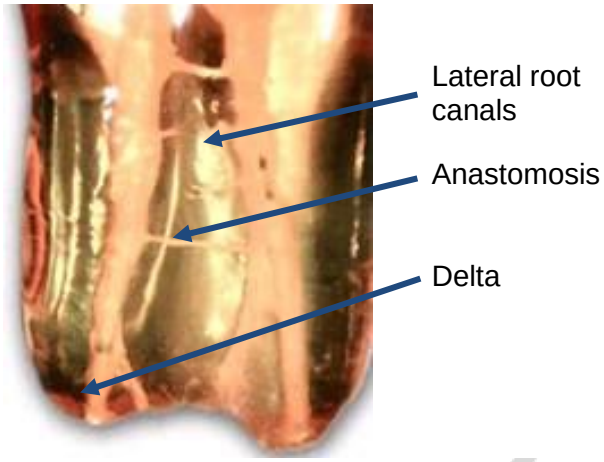

Figure 2. A root canal delta

Root canals in the apex of the root (Fig. 3) often have side branches anastomoses. Sometimes branch is located in the apical part of the channel, forming the so-called delta.

Figure 3. A tubular structure of the root canal dentin

Based on this, the root canals are classified by Weine (Fig. 4.)

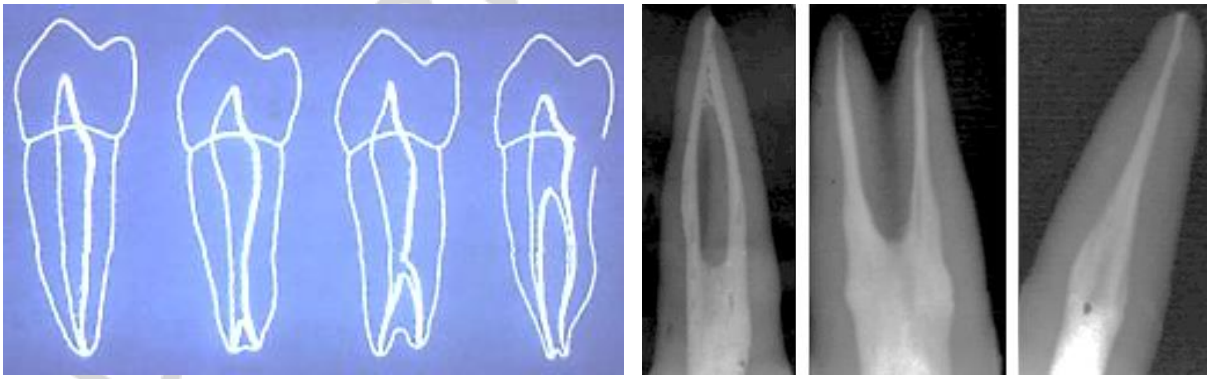

Figure 4. Weine classification of root canal system

Weine identified 4 types of branching of the root canal (Fig. 4):
– Type 1 — no branching;
– Type 2 — branching in the lower third, at the apex of the tooth root;
– Type 3 — branching in the middle third;
– Type 4 — branching begins in the upper third of the root canal.
Vertucci identified 8 types of branching of the root canal (Fig. 5):

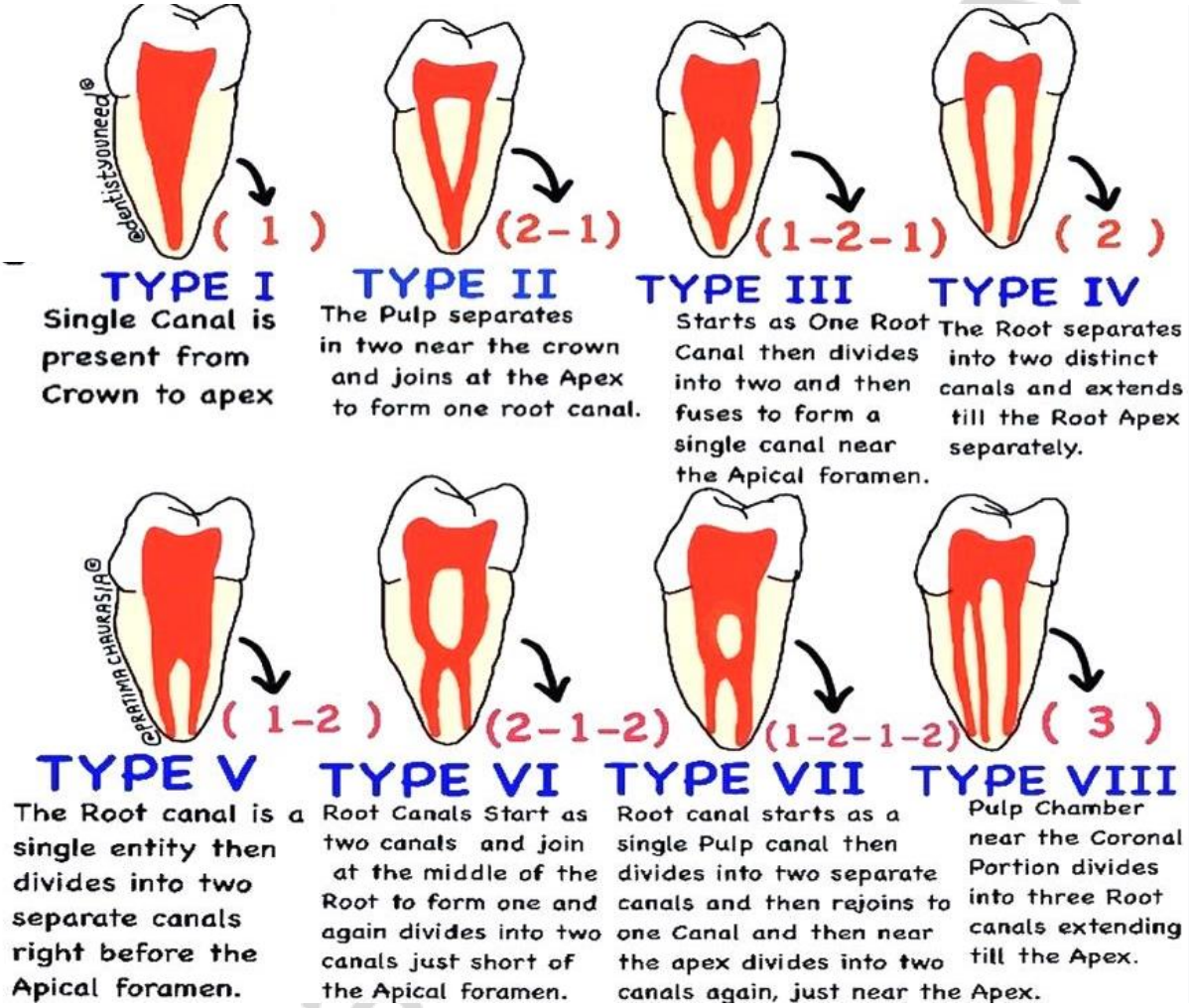

Figure 5. Vertucci classification of root canal morphology

ANATOMICAL AND HISTOLOGICAL STRUCTURE OF THE ROOT CANAL. PRELIMINARY X-RAY EXAMINATION AND ITS INTERPRETATION

The distance between the physiologic and anatomical opening tip of the root is app. 1–1.5 mm. proximately. Determination of length can be carried out using X-ray diffraction and electronic aids. Treatment should be made before the narrowest point in the root canal, to physiological holes (Fig. 6), which corresponds to the cement — dentin junction and does not reach radiographic apex 0.5–1.5 mm. Thus, preventing expansion of the apical foramen will not allow pushing the bacteria in the periapical space.

Figure 6. Anatomical opening (A) in physiological hole (B) (at a distance from the anatomical 0.5–1.0 mm holes), C — anatomical (X-ray) tip

Morphology and root canals disposed therein is different, including the differences between the shape of the root canal in the cervical, middle and apical thirds (Fig. 7).

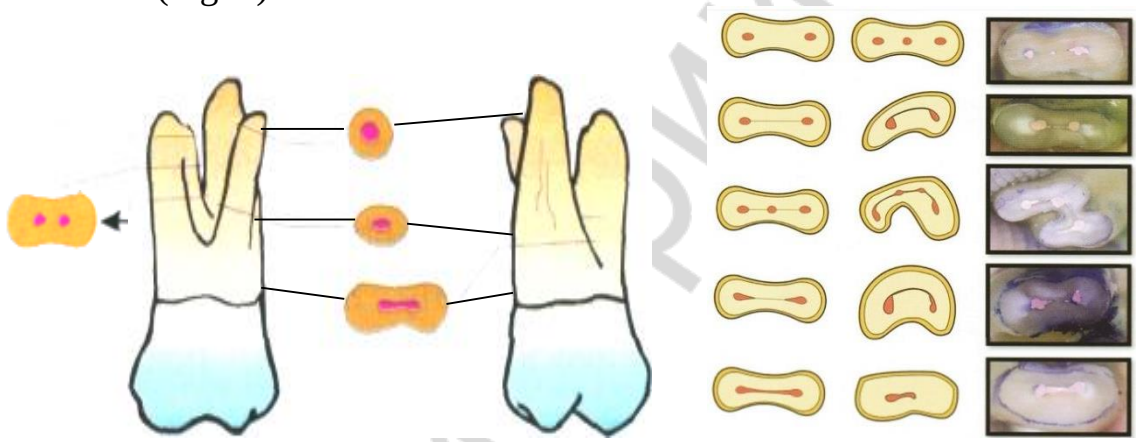

Figure 7. Root canal morphology

If we consider the canal shape in cross section, here it will be no less simple. In different root canals, it approaches a circle, oval, slit, "eight". Canal shape determines the shape of the root (Fig. 8). Most often roots are flattened in mesiodistal direction, in t buccolingual of slit-shaped root canals are rare.

Root canal treatment involves [8]:

– removing the damaged and infected pulp;

– shaping the entire root canal system;

– cleaning (chemically and mechanically) and disinfecting the entire root canal system;

– filling and sealing the root canal system;

– placing a direct restoration such as a composite filling or indirect restoration such as a crown (intracanal endo treated tooth reinforcement is required).

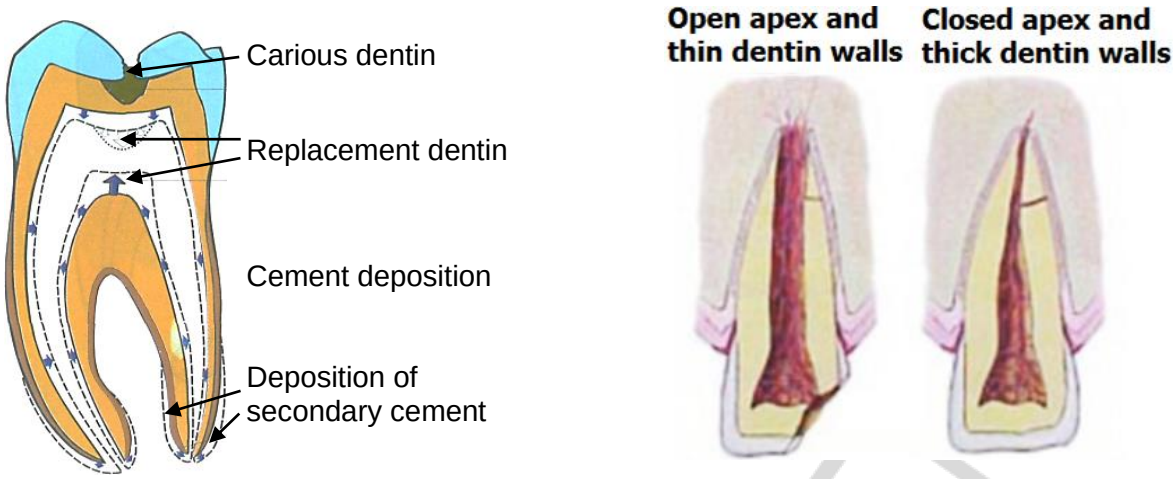

Figure 8. Age-related changes

ENDODONTIC TREATMENT

Endodontic treatment — a measure aimed at preserving the tooth. Purpose and objectives of endodontic treatment:

– proper mechanical and chemical root canal treatment;

– making the necessary root canal (conical) shape;

– antiseptic root canal cleaning.

Qualitative obturation (filling) of the root canal. With age, there are certain dental changes (Fig. 8). They consist primarily of the deposition of secondary dentine, which reduces the pulp space in both the longitudinal and transverse direction, alienates it from chewing surface and near the apex.

Preliminary X-ray examination allows a diagnosis to determine the features of the channels, their shape and direction, as well as changes to the periodontal treatment (Fig. 9). An important point in this step is the evaluation of the viability of the pulp.

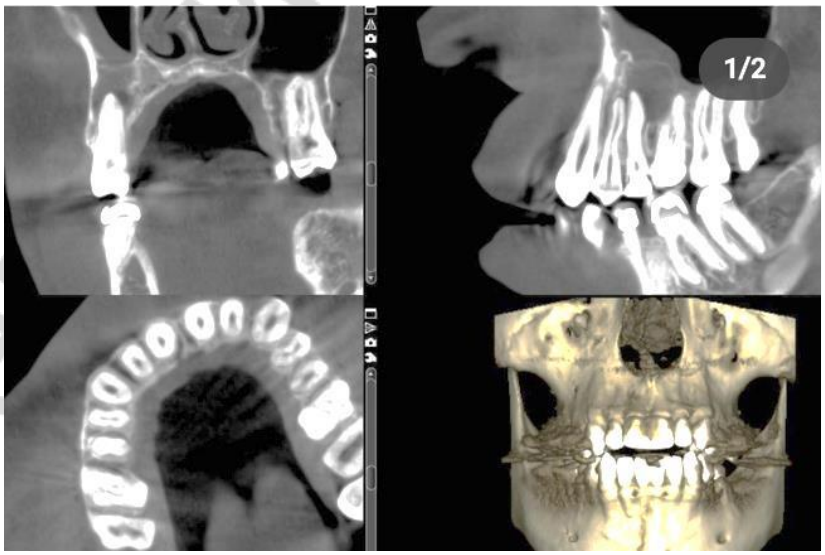

Figure 9. Preliminary X-ray examination

Anesthesia. Premedication: reducing emotional stress and pain sensitivity. Endodontic treatment requires the use of anesthetics to relieve pain.

Tooth isolation. Modern saliva ejectors, vacuum cleaners, dry tips, cofferdam help to prevent entrance of saliva into the dental cavity. The best method of providing insulation of a tooth from saliva is a cofferdam. Cofferdam provides security for patients, because eliminates the ingress of endodontic instruments and strong antiseptics in respiratory or intestinal tract. In case the dam is recommended use locking system tools.

Creating access to the canal is carried out by taking into account the topography of the tooth cavity (Fig. 10).

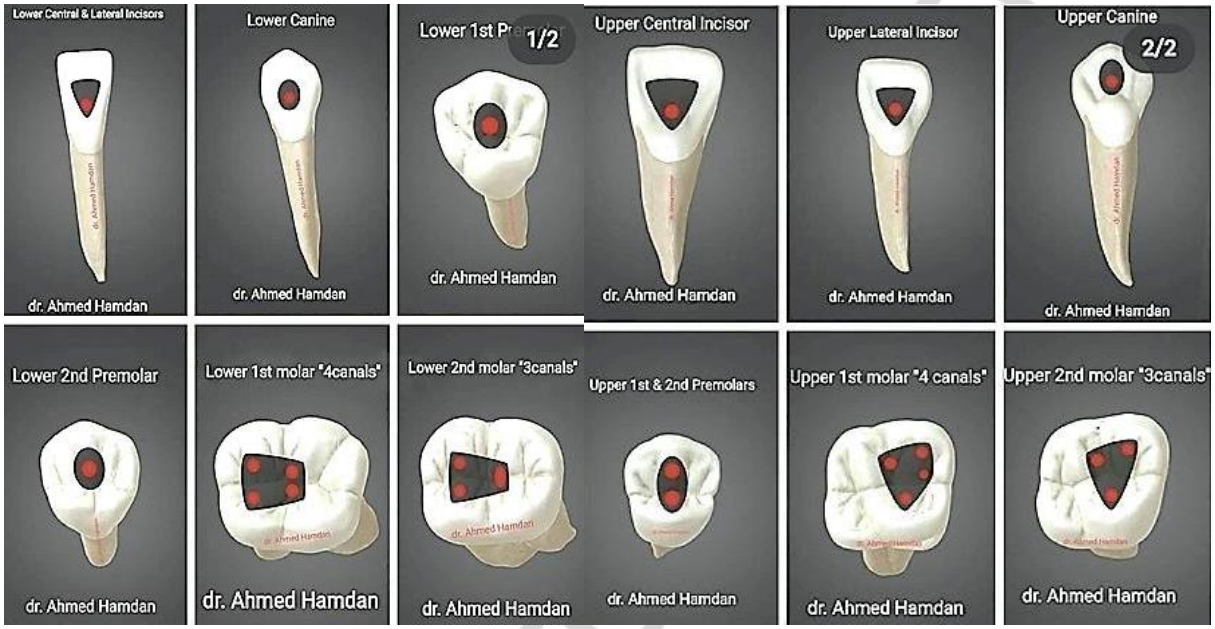

Figure 10. Access to the root canals

Anatomical features of teeth affect the size, shape and direction of root canal preparation. Proper dental cavity preparation provides free access to the root canals.

Pulp removal is carried out in 2 stages. *Amputation of coronal part of the pulp* is carried out with a sterile round **bur** or excavator. The main ways of influencing the pulp when performing endodontic manipulation:

– Vital;

– Devital.

Extirpation (next stage) is removal of pulp. Different diameters broach or K-files (with narrow channels) are used for this purpose. A broach is slowly introduced into the root canal until light contact with the walls of the channel in the apical portion, with 180° rotation clockwise and captures slurry withdrawn from the channel. Decay is removed from the pulp canal chamber, fractionally under antiseptic irrigation.

Methods for determining the working length			
X-ray	Table of average root length	Tactile	Apex location

Determining the working length of the instrument. Working tool length is the distance from the outer edge of the tooth (the reference point) to the physiological narrowing in the apical part of the root of the tooth. Processing and shaping of root canals **is done** to this level. Working tool length equals the length of the tooth minus 0.5–1.5 mm.

Radiographic accounts for more than 92 % of the apical constriction 0.5 to 1.5 mm from the anatomical (X-ray) tops. Based on the anatomy of the apex researchers recommend root canal treatment by 0.5–1.5 mm from the radiographic apex of the root, since the area of the apical constriction is in this range with the highest statistical probability.

Determining the effective length:

– diagnostic radiography;

– endodontic line;

– file with the stopper;

– apex locator;

– Table of length dimensions of tooth roots (Table).

Table of length dimensions of tooth roots

Maxilla (mm)	**average**	25	23	27	21	22	22	21	20
	max	27,5	25	29,7	23	24	24	23	18
	min	22,5	21	24	19	20	20	19	16
The tooth number		1	2	3	4	5	6	7	8
Mandible (mm)	**min**	19	20	23,5	20	20	20	19	16
	max	23	24	28,5	24	24	24	23	20
	average	21	22	26	22	22	22	21	18

The procedure for measuring the working length of the root canal using apex locator:

1. According to the X-ray table or find the average value of the length of the tooth minus 0.5–1.0 mm.

2. Specified distance mark stopper with endodontic line on the scan tool.

3. Fix the tool in the diagnostic electrode apex locator and measure the working length of the root canal in accordance with the instructions for the device.

4. Detach the diagnostic tool gently from the diagnostic electrode apex locator, fix the root canal with a cotton ball or wax and conduct X-ray of the tooth by the rule of isometric projection.

5. The tip of the tool is at a distance of 0.5–1.0 mm from the radiographic apex of the tooth, the working length is measured correctly, if not, correction is necessary.

Definition of working tool length.

SIGNIFICANCE OF WORKING LENGTH

1. Determines how far into the canal the instruments are placed & worked & thus how deeply the tissues, debris, metabolites are removed.
2. Limits the depth to which the canal filling may be placed.
3. Affects the degree of pain& discomfort that the patient will feel following the appointment.
4. If calculated within correct limits, it will play an important role in determining the success of the treatment & conversely, if calculated incorrectly, may cause the failure of treatment.

Failure to accurately determine & maintain working length. A length too long can lead to (Fig. 11):

1. Perforation through apical constriction.
2. Overfilling or overextension.
3. Increased incidence of postoperative pain.
4. Prolonged healing period.
5. Lower success rate.

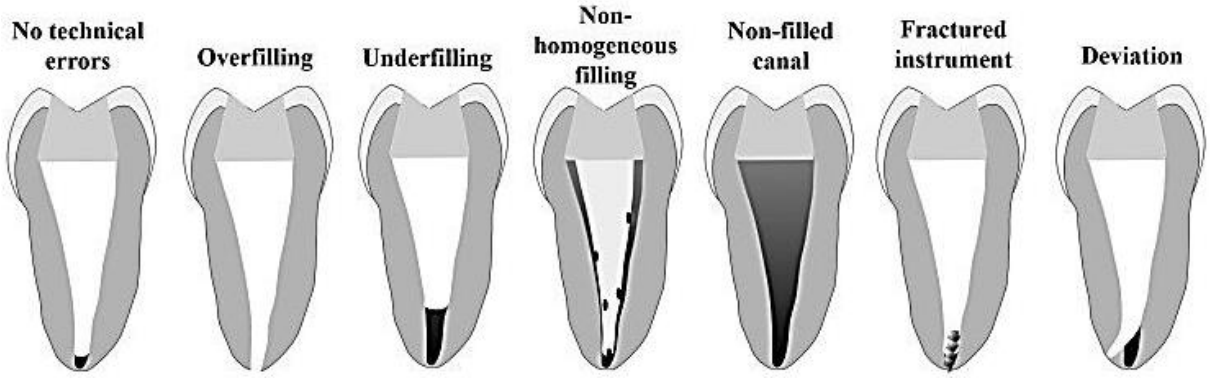

Figure 11. Failure to accurately determine & maintain working length

Short working length can lead to:

– incomplete cleaning;
– underfilling;
– persistent discomfort;
– incomplete apical seal, apical leakage which supports the existence of viable bacteria and contributes to a periradicular lesion;
– lower success rate.

APICAL ROOT ANATOMY & ITS IMPACT ON WL

Histological evidence of apical part Table of length dimensions of tooth roots. Dental pulp destroyed the cemental-dentinal junction. Apical view of tooth with a C-shaped root formation (Fig. 12).

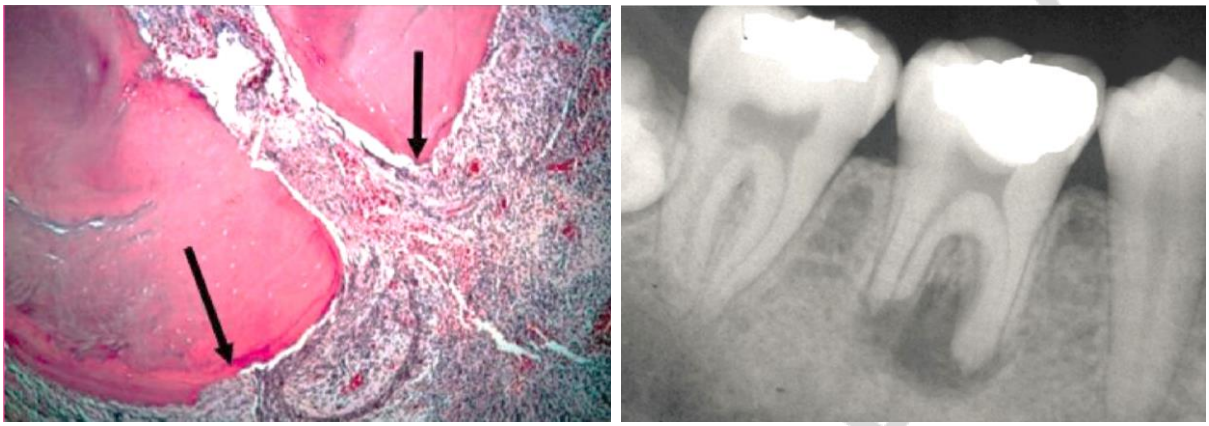

Figure 12. Mandible molar with apical root resorption on external cement. Resorption due to a necrosis, infections (black arrows)

Note root morphology around the canal exits as cement invaginates into the foramen. K-files (arrows) are exiting from the canal long before they reach the actual root surface. Actual foramina are much larger than canals, as indicated by widths of the red lines.

Working length could be destructive measurement to periapical tissue (Fig. 13).

Figure 13. Working length measurement could be destructive to periapical tissue

These potential anatomic variances have a major impact on the precise region or location for determining the working length and termination of root canal instrumentation and obturation.

Prior to establishing a definitive working length, coronal access to the pulp chamber must provide a straight-line access into the canal orifice, by facilitating subsequent canal penetration.

In anterior teeth, failure to remove the lingual ledge or incisal edge often impedes this straight-line access, resulting in lack of depth penetration to the CDJ, failure to locate all canals present, or instrument penetration into the canal wall with ledge formation.

In posterior teeth, primarily molars, or multirooted premolars, failure to remove cervical ledges or bulges results in missed canals or binding of the penetrating instrument in the coronal third of the canal with ledge formation. The ability to penetrate unimpeded to the CDJ is crucial to determining the working length.

HOW TO PREVENT LOSS IN WL

In this era of improved illumination and magnification, working length determination should be to the nearest 0.5 mm, which is the maximum resolution of the naked eye in working distance.

Measurement should be made from a secure reference point on the crown that can be identified and monitored accurately, in close proximity to the straight line path of the instrument.

A silicon stopper is a common aid for evaluating the working length measurement and returning to a secure reference point (Fig. 14).

Figure 14. Silicon stoppers

Care must be taken to assure that the stopper is placed on the file and measured at a right angle to the file. Otherwise, differences in length of a millimeter or more between files may occur, leading to either perforation and stripping of the apical foramen or inadequate cleaning and shaping of the apical seat, with corresponding loss of length.

Commercial stoppers are made of:

– metal;

– silicon rubber;

– plastic (Tear-drop, Round shaped).

Advantages:

1. Do not have to be removed during sterilization.

2. In curved canals, to indicate the curvature-special tear shaped or marked rubber stops can be positioned with the direction of the curve placed in a pre-curved stainless steel instrument.

Disadvantages:

1. Time consuming.

2. May move up and down the shaft which may lead to preparations short or past the apical constriction

Metal or silicone stoppers have marks of the working length. The stopper must clearly correspond to a cusp tip and rest firmly on it. For electronic determination of working length, the silicone stopper (left) is better than a metal stopper (right) because the metal stopper can cause a short circuit.

Length adjustment of the stopper attachments should be made against the edge of a sterile metric ruler or gauge made specifically or Endodontic.

Guidener Endo-M-Bloc (DENTSPLY/Maillefer). Has 32 depth guides in 2 rows. Front row indicators from 10–30 mm in 1 mm.

Some instruments have millimeter marking rings etched or grooved into the shaft. These act as a built-in ruler with the markings placed at 18, 19, 20, 21, 22, 23 & 24 mm.

METHODS OF WORKING LENGTH DETERMINATION

Radiographic method (Fig. 15):

– Best's method;

– Bregman's method;

– Bramante's method;

– Grossman formula;

– Ingles method;

– Weine's method;

– Kutler's method;

– Radiographic grid;

– Euclidean endometry;

– Xeroradiography;
– Direct digital radiography.

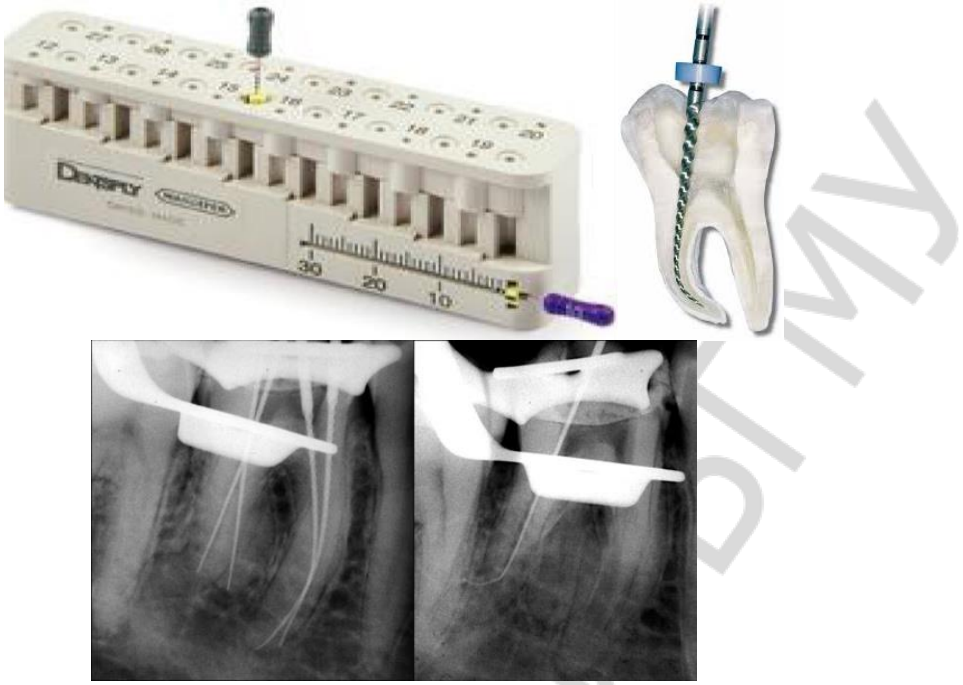

Figure 15. Radiographic Non-Radio graphical methods of Xray diagnostic

Non-Radio graphical methods:
– digital tactile sense;
– apical periodontal sensitivity;
– electronic apex locator;
– paper point method.

School of thoughts:

1. Those who follow this concept say that the CDJ is impossible to locate clinically & radiographic apex is the only reproducible site available for length determination.

2. Those who don't follow this concept say the position of radiographic apex is not reproducible. Its position depends on a number of factors like tooth angulation, position of film holder, adjacent anatomic structures, etc.

TECHNIQUES

BISECTING ANGLE TECHNIQUE
PARALLELING TECHNIQUE
When two superimposed canals are present, go for:

A. Take 2 individual radiographs with instrument placed in different canal at each time.

B. Insert two different instruments — K-file in one canal, H-file in the other canal and take radiographs at different angulations.

C. Apply SLOB rule, that is expose tooth from medial or distal horizontal angle, the canal which moves to same direction is lingual, whereas the canal which moves in the opposite direction is buccal.

Best's method. Introduced in 1960. A steel pin measuring 10 mm is fixed to the labial surface of root with utility wax, keeping the pin parallel to long axis of tooth radiograph is taken (Fig. 16).

Then measurements are made with the help of a BW gauge.

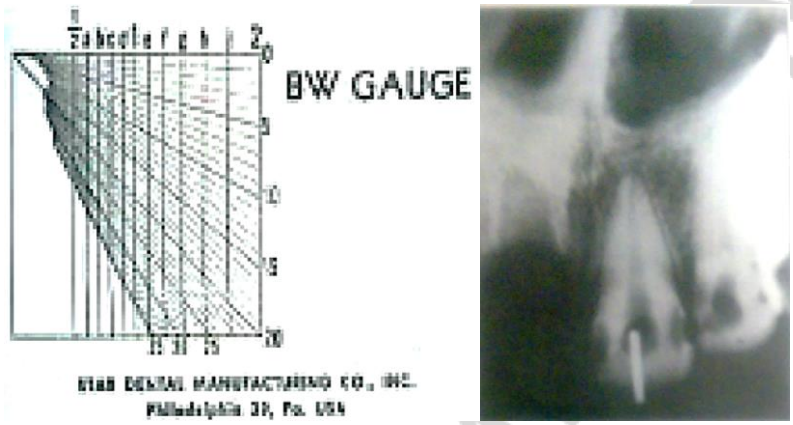

Figure 16. Best's method

Bregman's method. 25 mm-long flat probes are prepared & each has a steel blade fixed with acrylic resin as a stopper, leaving a free end of 10 mm for placement into the root canal (Fig. 17). This is placed in the tooth until the metallic end touches the incise edge or cusp tip of the tooth.

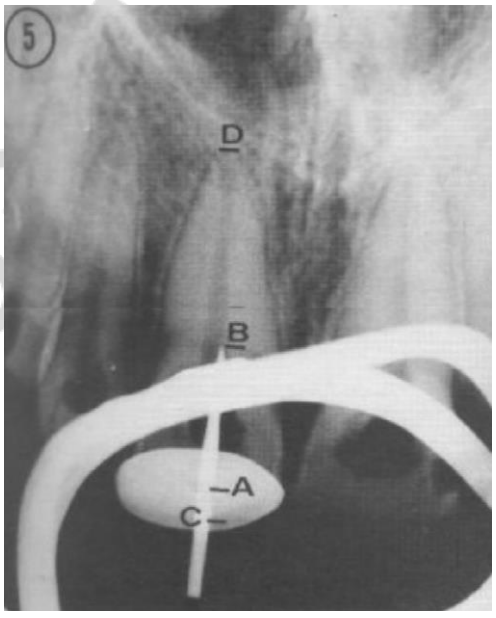

Figure 17. Bregman's method

Then a radiograph is taken & the following is measured:

ALT: apparent length of tooth;

RLI: real length of instrument;

ALI: apparent length of instrument;

RLT = RLI × ALT / ALI.

Bramante's method. Introduced in 1974. Used stainless steel probes of various calibres length. They are bent at one end at right angles & this bend is inserted partially into acrylic resin in such a manner that its internal surfaces in flush with the resin surface contacting tooth surface. The probe is introduced in the canal in such a way that the resin touches the incisal or cusp tip taking care to see that the bent segment of the probe would be parallel to mesiodistal diameter of crown thus making it possible to visualize on the radiograph.

In this radiograph the reference points are as follows:

A: internal angle of intersection of incisal&radicular probes segment.

B: apical end of probe.

C: tooth apex.

Tooth length is calculated in 2 ways:

1. Measure radiographic image length of probe A-B, measuring radiographic image length of tooth from A-C & then measuring real length of probe (Fig. 18).

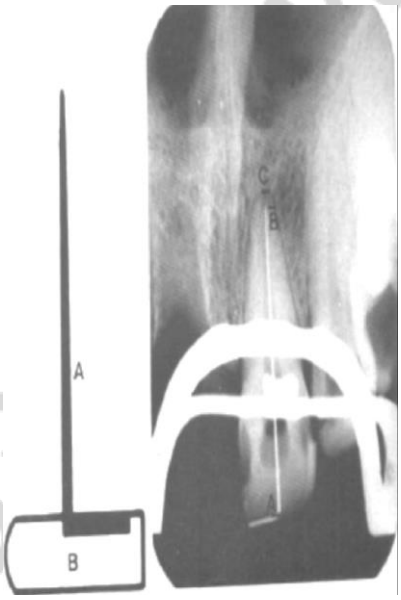

Figure 18. Stainless steel probes of various calibres length

Now the following equation is applied:

CRD — real tooth length;

CRS — real probe length;

CAD — tooth length in radiograph;

CAS — instrument length in radiograph;

CRD = CRS × CAD / CAS.

2. Measure distance bet apical end of probe & radiographic apex. Add or subtract to obtain correct WL.

Grossman's method disadvantages (Fig. 19). Wrong reading can occur because of:

– variations in angles of radiograph;
– curved roots;
– S-shaped, double curvature canals;
– a small error will be multiplied.

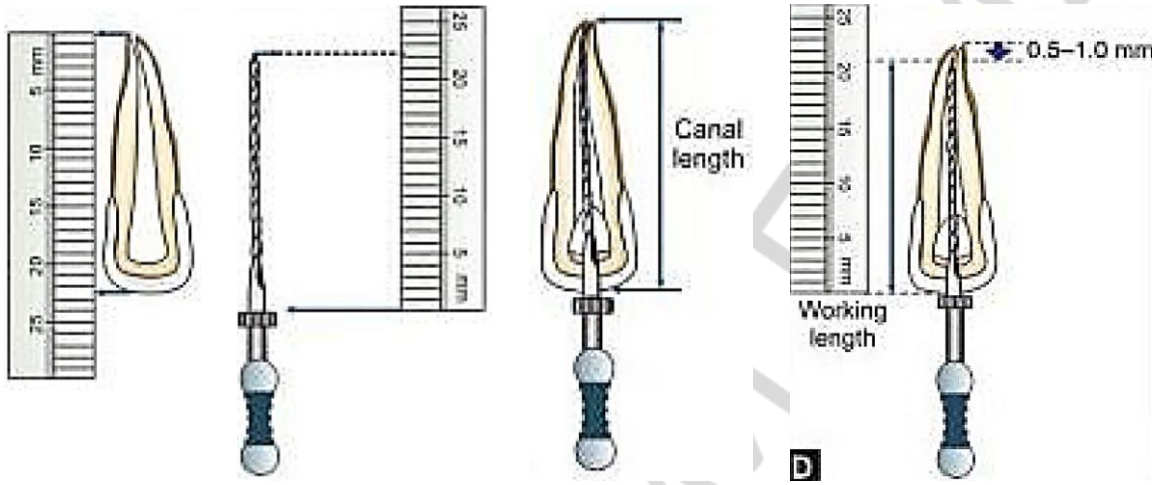

Figure 19. Grossman's method

Ingle's method. This method was recommended by Ingle and reviewed by Bramante and Berber, and reported that this method is superior to other methods (Fig. 20).

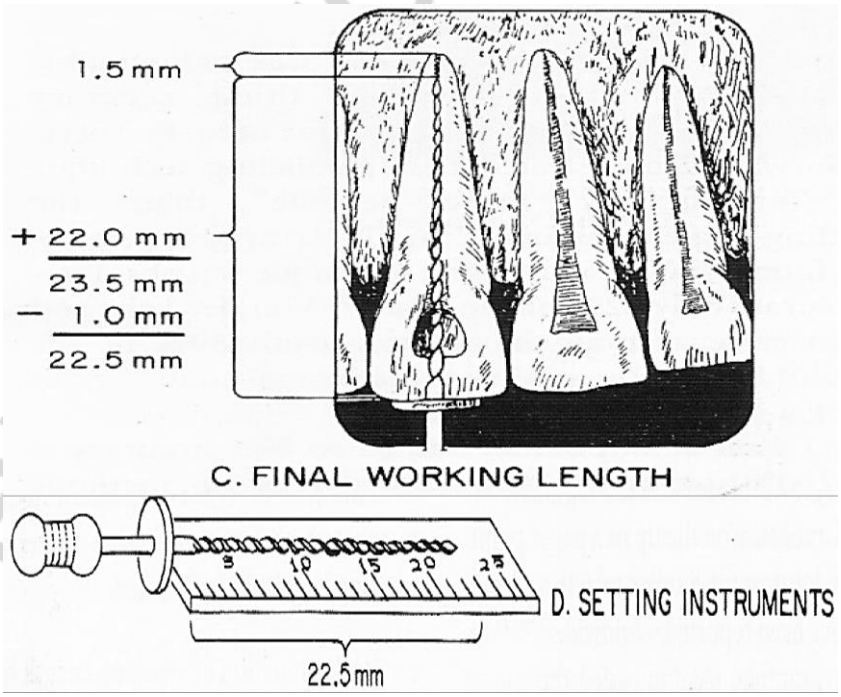

Figure 20. Ingle's method

Weine's modification in length subtraction (Fig 21):

1) no desorption — subtract 1 mm;
2) periodical bone loss — subtract 1.5 mm;
3) periodical bone loss root apex desorption — subtract 2 mm.

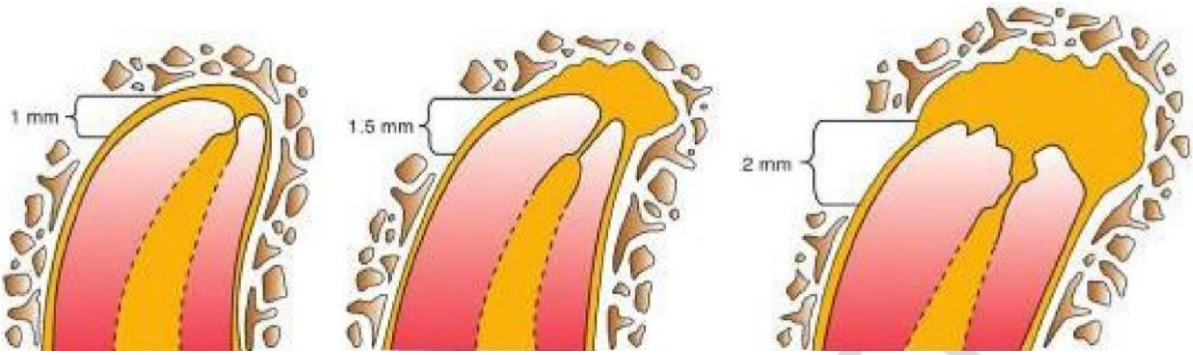

Figure 21. Weine's modification in length subtraction

Kuttler's method. In young patients, average distance between minor and major diameter is 0.524 mm in case of older patient its 0.66 mm.

Advantages:

– minimal errors;
– has shown many successful cases.

Disadvantages:

– requires radiograph of highest quality;
– time consuming;
– complicated.

X-ray grid system. Everett & Fixottin, 1963. Consists of lines1mm apart running lengthwise & crosswise. Every 5th millimeter is accentuated by a heavier line to make reading easier. The grid is taped to a film to lie in-between.

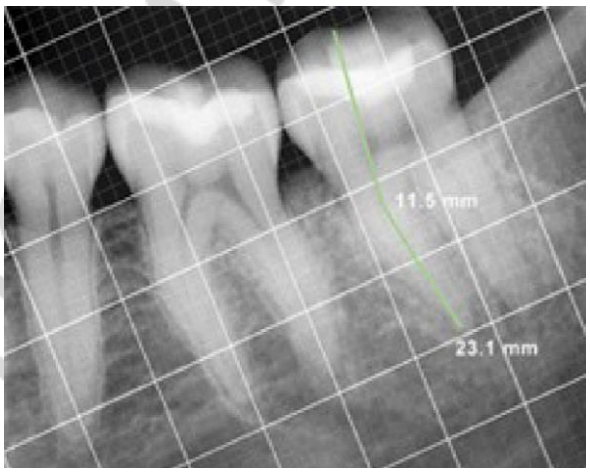

Figure 22. X-ray grid system

Advantages: simple method; no need for calculations.

Disadvantages: cannot be used if radiograph is bent during exposure.

Euclidean endometry. It uses 2 geometrically distorted radiographs in determining real length of tooth. The 2 radiographs are taken with a cone fitted with a "updegraves XCP" (extension cone paralleling method) device at 2 different vertical angulations. The actual tooth length is calculated by geometric principles from the length of the tooth in the two radiographs & the known **vertical** angular differences.

Walton and Torabinejad method. Diagnostic film taken using paralleling technique & length is measured. From this 3 mm is subtracted to obtain estimated working length. Place stoppers at this length to a series of files. Then radiograph is taken. Corrected working length is determined by measuring the discrepancy between the tip of the file and the radiographic apex. File is then adjusted 1–2 mm short of the radiographic apex N 8, N 10 files are not used.

Xeroradiography. The term Xeroradiography is derived from the Greek word XEROS which literally means dry which differentiates this from the conventional photochemical system.

Direct digital radiography. In this digital image is formed which is represented by spatially distributed set of discrete sensors & pixels (Fig. 23).

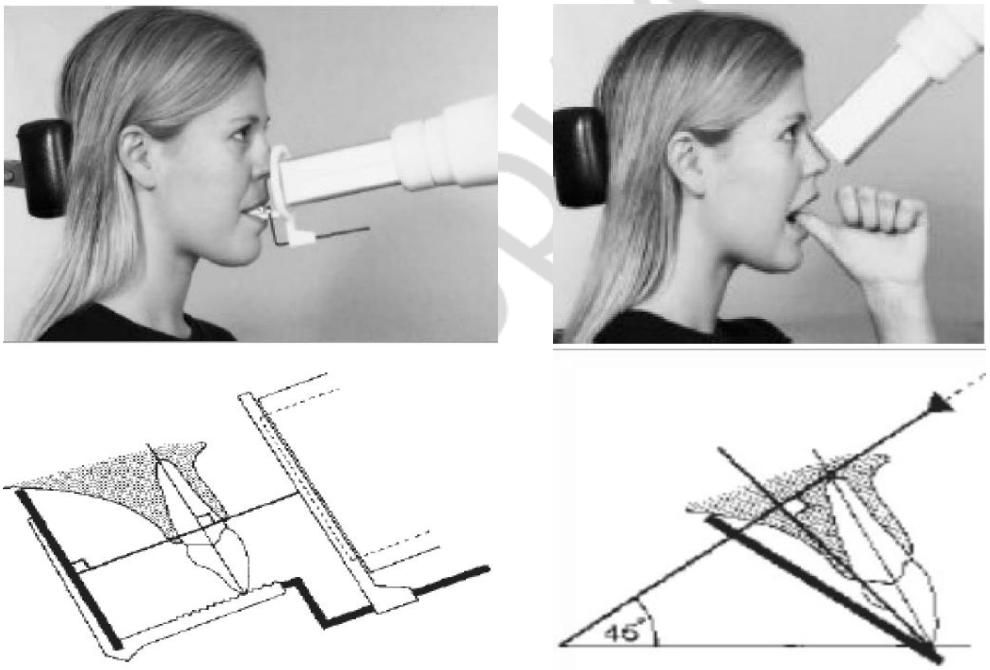

Figure 23. The method was invented by Dr. Frances Mouyens in 1984 (paralleling and bisecting angle technique)

Advantages:
– low radiation dose;
– dark room is not required as instant image is viewed;
– quality of the image is consistent;
– greater exposure latitude;
– image distortion from bent films is eliminated.

Disadvantages:

– expensive;

– large disk space required to store images;

– soft tissue imaging is not very accurate;

– bulky sensor with cable attachment can make placement in <b> phosphor imaging system.

Images captured on a phosphor plate as analogue information &converted into digital format when plate is processed.

Advantages:

– low radiation dose;

– instant images are formed;

– image manipulation facilities;

– receptor is the same size as film.

Disadvantages:

– expensive;

– slight inconvenience due to plastic wraps around phosphor plates;

– large disk space to store images.

Advantages and disadvantages of radiographic method.

Advantages:

– visible anatomy of tooth;

– visible curvature in roots;

– visible relationship b/w adjacent teeth & anatomic structures.

Disadvantages:

– varies with different observers;

– superimposition of anatomic structures;

– 2D view of a 3D object;

– radiation exposure;

– cannot interpret if apical foramen has buccal or lingual exit;

– limited accuracy;

– time consuming.

Digital tactile sense.

Advantages: timesaving; no radiation exposure.

Disadvantages:

– in case of narrow canals, one may feel increased resistance as file approaches apical 2–3 mm;

– in case of teeth with immature apex, instrument can go periapical;

– in case of anatomical variations in apical constriction, sclerosis, resorption, tooth type and age this method becomes unreliable;

– Svedberg et al. reported an accuracy of just 64 % using digital tactile sense;

– this method should be considered supplementary to high-quality, carefully aligned, parallel, working length radiograph or an apex locator.

Periodontal sensitivity test. This method does not provide accurate readings, for example in case of narrow canals; instrument may feel increased resistance in apical 2–3 mm. In immature apex, file goes beyond apex.

In case of canals with necrotic pulp, instrument can pass beyond apical constriction, and in case of vital or inflamed pulp, pain may occur several millimeters before periapex is crossed by instrument.

Paper point measurement method. This method, however, may give unreliable data (Fig. 24):

– if the pulp is not completely removed;

– if the tooth is pulpless but a periapical lesion rich in blood supply is present;

– if paper point is left in canal for a long time.

Figure 24. Usage of paper points

Electronic apex locator. In addition to radiography, tactile sensation has been used with questionable success, plus the drawbacks cited about radiographic length determination along with increasing concern about radiation exposure, the introduction &development of apex locators was received with enthusiasm (Fig. 25).

Figure 25. Electronic apical foramen locator

These devices do not assess the position of the root apex and the name “electronic apex locator” is not appropriate; “electronic apical foramen locator” or “electronic root canal length measurement device” as a generic name would be more appropriate.

The ability to distinguish between minor & major diameter of apical terminus is the most important for creation of APICAL CONTROL ZONE.

The apical control zone is the mechanical alteration of the apical terminus of root canal space that provides resistance & retention form of the obturating material against the condensation pressure of obturation (Fig. 26).

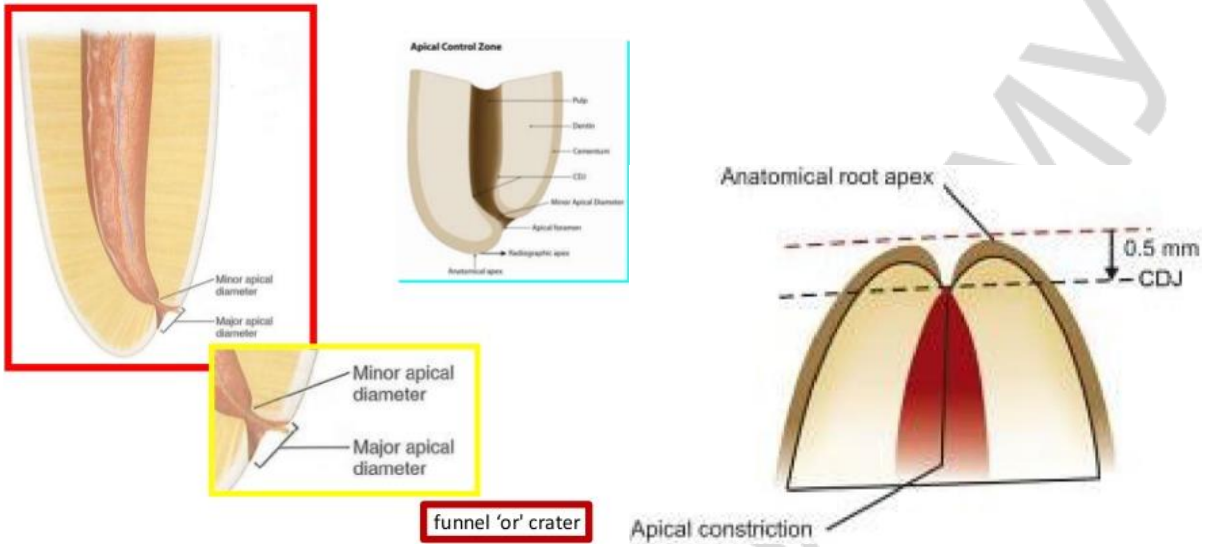

Figure 26. Apical control zone

Parts of apex locator:

– the lip clip;

– the file clip;

– electronic device;

– cord which connects the above three parts.

Uses of apex locators:

1. Provide objective information with high degree of accuracy.

2. Used when apical portion of canal is constricted.

Impacted teeth (Fig. 27):

– zygomatic arch;

– overlapping roots;

– excessive bone density.

3. Used in patients with gag rifles and without X-ray.

4. In pregnant ladies to reduce radiation exposure.

5. Useful in children, disabled patients, heavily sedated patients, etc.

6. Can be used in teeth with incomplete root formation, requiring apex fixation & to determine WL in primary teeth.

7. Valuable tool for:

– detecting site of root perforations;

– testing pulp vitality;

– determination of perforations caused during postpreparation;

– detecting horizontal or vertical root fractures;
– detecting internal or external resorption.

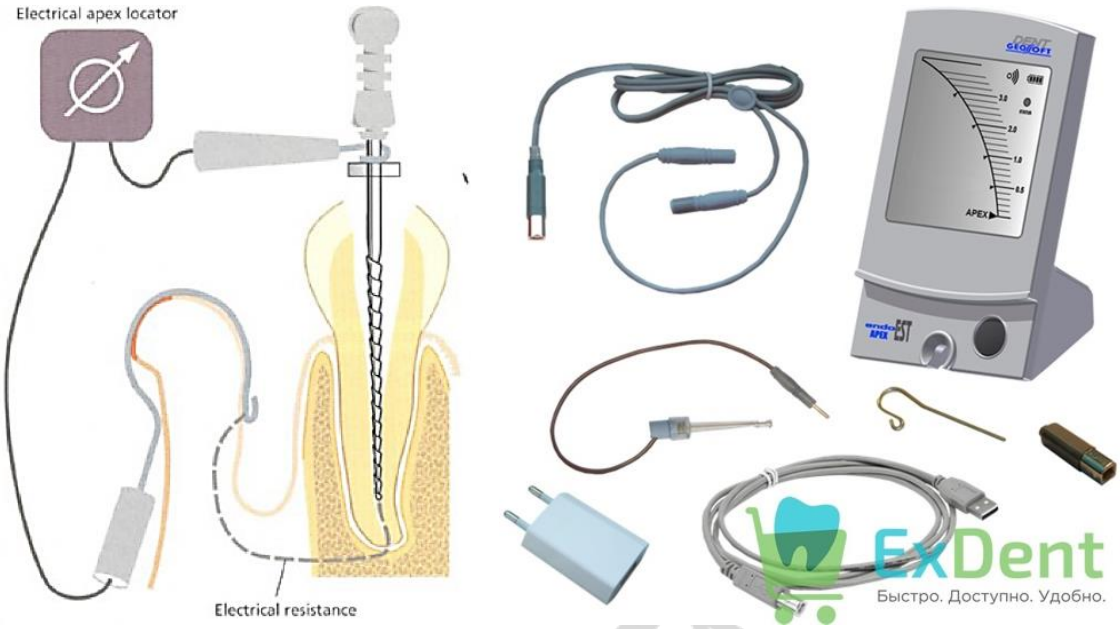

Figure 27. Uses of apex locators

Basic conditions for accuracy:
– canal should be relatively dry;
– canal should be free from debris;
– no cervical leakage;
– no blockage or calcification of canals;
– proper contact of file with canal walls & apex.

TYPES OF APEX LOCATORS (CLASSIFICATION)

BASED ON DIRECT CURRENT
BASED ON ALTERNATING CURRENT
ORIGINAL OHM
METER USED BY SUZUKI & SUNANDA
RESISTANCE TYPE
- Root canal meter
- Endometricity

IMPEDENCE TYPE
- son explorer

FREQUENCY TYPE
SUBTRACTION TYPE
- Ended
- Nelson ultimate

RATIOTYPE
2 FREQUENCIES
- Root ZX

5 FREQUENCIES
- AFA
- Apex finder

FIRST GENERATION APEX LOCATOR
- Resistance apex locators
- Measures opposition to flow of direct current (i.e. resistance)
- Endoroot canal meter (Onuki Medical Co. Japan)
  – endometric meter
  – endometric meter S II (Onuki Medical Co.)

Advantages:
1. Easily operated
2. Digital readout
3. Audible indication
4. Detect perforation
5. Can be used with K-file

Disadvantages:
1. Requires a dry field
2. Patient sensitivity
3. Requires calibration
4. Requires good contact with lip clip
5. Cannot estimate beyond 2 mm

SECOND GENERATION APEX LOCATOR
- Inoue introduced the concept of impedance based AL
- Principle: measures opposition to flow of alternating current or impedence egs:
  – Sonoexplorer
  – Apexfinder
  – endoanalyzer
  – Digipex
  – Digipex II
  – Exact-Apex

Advantages:
1. Does not require lip clip.
2. No patient sensitivity.
3. Analogmeter.
4. Detects perforations.

Disadvantages:

1. No digital readout.
2. Difficult to operate.
3. Requires coated probes.

THIRD GENERATION APEX LOCATORS

• Based on the fact that different sites in the canal give difference in impedance (8 KHz) & low (400 Hz) frequencies

• Difference in impedance is least in the CORONAL part& greatest at the CDJ

• As impedance is influenced by frequency of current flow, these are also known as frequency dependent

• They should be called comparative impedance because they measure magnitudes of impedance which is converted to length information

• Endex (original 3rd gen AL)

• Root ZX (shaping &cleaning of canals with simultaneous monitoring of WL)

• Mark V plus

• Co-pilot

• Endoanalyser 8005

Advantages:

1. Easy to operate
2. Audible indication
3. Can operate in the presence of fluids
4. Analogue readout
5. Uses K-file

Disadvantages:

1. Requires lip clip
2. Chances of short circuit
3. Needs fully charged battery
4. Must calibrate each canal

FOURTH GENERATION APEX LOCATORS

• Measures resistance & capacitance separately

• There can be different combination of values of capacitance and resistance that provides the same foraminal reading

• This is broken down into primary components and measured separately for better accuracy and thus fewer chances of errors

• Eg: neosono ultima ZX sybronendo

FIFTH GENERATION APEX LOCATORS

• It uses multiple frequencies rather than the dual frequencies of the third and fourth generations of apex locators, so it works in dry or wet canals and requires no calibration. Eg: RAYPEX

SIXTH GENERATION APEX LOCATORS

Also called adaptive apex locators:

• Multi-frequency operating system

• Sound operated switching device can produce different kinds of sound to indicate the different positions of file in the root canal. Dry and wet condition are also available for accurate reading

COMBINATION OF APEX LOCATORS AND ENDODONTIC HANDPIECES

Is cordless electric endodontic handpiece with built in Root Zx apexlocator. The handpiece with Ni-Ti rotary instruments that rotate at 280 ± 50 rpm.

• Autostart-stop mechanism
• Autotorque reverse mechanism
• Autoapical reverse mechanism

The Root ZX is not capable of detecting the 0.5 mm from the foramen position and thus, should only be used to detect the major diameter (i.e. contrary to manufacturer claims, Apex Locators can only reliably determine when the file is actually touching the PDL at the apex. Set your working length 1 to1.5 mm back from this length to avoid over-instrumentation).

ENDY 7000

• Endodontic handpiece connected to an end apex locator

• Reverses the rotation of the instrument when it reaches a point in the apical region preset by the clinician.

SAFY ZX

• New development of ultrasonic systems
• Handpiece +apex locator
• Uses Root ZX to monitor location of file during instrumentation
• Minimizes danger of overinstrumentation

Comparison of accuracy of two electronic apex locators in the presence of various irrigants: an in vitro study.

Aim: This study was designed to compare the accuracy of Root ZX and SybronEndoMini EALs, in the presence of various irrigants.

Conclusion: The measurements of Root ZX in the presence of saline & 1 % NaOCl were closer to the AL and with no significant difference between them,

while significant differences were observed with 2 % CHX & 17 % EDTA. Sybron Mini, in the presence of saline, 1 % NaOCl and 17 % EDTA, gave measurements which were shorter than the AL, whereas, in the presence of 2 % CHX, WL was more accurate. Although statistically significant differences existed between the irrigants the majority of there adings were within the acceptable range of ± 0.5 mm for both EALs. Over all accuracy of measurements by Root ZX and Sybron Mini was 88.3 % and 87.5 %, respectively (J. Conserv. Dent. 2012. Vol. 15. P. 178–82).

An in vitro evaluation of the accuracy of the Root-ZX in the presence of various agents.

• The purpose of this study was to evaluate the accuracy of the Root ZX in vitro in the presence of a variety of endodontic irrigants: Saline, 2 % Lidocaine with 1 : 100,000 epi., 5.25 % NaOCl, RC Prep & 3 % hydrogen peroxide.

Results: The most deviation (raw numbers) occurred with NaOCl, but it was not statistically significant. The Root ZX was able to consistently determine the location of the apical foramen (within approximately ± 0.4 mm) in the presence of any of the tested irrigants (only fill the canal, not the chamber during EAL use) (J. Endodon. 2001. Vol. 27. P. 209–11).

Evaluation of working length determination methods: an in vivo /ex vivo study.

This comparative study was done to determine the accuracy in measuring the working length of root canal using tactile method, electronic apex locator and radiographic method, in vivo and comparing the lengths so measured to the actual working length, ex vivo, after extraction.

The results indicated that among the three methods, the electronic apex locator showed the highest accuracy and the highest reliability for working length determination (Indian J. Dent. Res. 2007. Vol. 18(2). P. 60–2).

An in vivo evaluation of different methods of working length determination

• The purpose of this in vivo study was to compare the ability of digital tactile, digital radiographic and electronic methods to determine reliability in locating the apical constriction.

Result: The percentage accuracy indicated that EAL method (Root ZX) shows maximum accuracy, i.e. 99.85 % and digital tactile and digital radiographic method (DDR) showed 98.20 and 97.90 % accuracy, respectively (J. Contemp. Dent. Pract. 2013. Vol. 14(4). P. 644–8).

Comparison of working length determination using apex locator, conventional radiography and radio visiography: an in vitro study.

• The purpose of this study was to compare the working length determination done using three methods, namely, apex locator (Foramatron D-10, Parkell), radiovisiography (Planmeca) and conventional radiography

Result: The results revealed that all the three methods located the apex nearly as accurately as the actual root canal length obtained by histological ground sectioning, and among three methods apex locator being the closest to the actual root canal length (Journal of contemporary dental practice. 2012. Vol. 13(4). P. 550).

Precision of Endodontic Working Length Measurements:
– A Pilot Investigation Comparing Cone-Beam Computed
– Tomography Scanning with Standard Measurement
– Techniques

• The study was conducted to evaluate the utility and precision of already existing limited CBCT scans in measuring the endodontic working length, and to compare it with standard clinical procedures

• Results suggested that great correlation was found between the endodontic working length as measured in the CBCT images and the EAL (JOE August 2011).

RECENT ADVANCEMENTS IN RADIOGRAPHIC METHOD

Laser optical disk storage. Laser optical disks use full medium to store radiographic images. An 8-inch optical disk is capable of storing up to 10,000 images with a 0.5 secret rieval & display time. The image is recorded by a focused laser beam heating a thin tell urium suboxide at specific points on the optical disk. When compared with normal radiographs, this method has been shown to produce images of superior diagnostic merit.

Cone beam computed tomography (CBCT). Cone beam computed tomography may prove to be more efficient and economical than either conventional tomography or computed tomography. CBCT uses a round or rectangular cone-shaped X-ray beam centered on a 2-dimentional X-ray sensor to scan a 360 degree rotation about the patient’s head. The radiation dose delivered to the patient as a result of one CBCT may be as little as 3 % to 20 % that of conventional CT scan.

TEST-CONTROL QUESTIONS

1. Diagnostic methods that ensure effectiveness of endodontic treatment:
   a) X-ray examinations;
   b) digital research;
   c) optical research;
   d) physiological research.

2. Additional facilities to ensure the effectiveness of endodontic protection:
   a) X-ray examination;
   b) endodontic ruler;
   c) apex locator;
   d) photopolymerizer.
3. To determine the length of the root canal the following methods are used:
   a) radiography;
   b) thermodiagnostics;
   c) electroodontodiagnostics;
   d) ultrasonic.
4. To find the orifices of root canals the following can be used:
   a) excavator;
   b) periodontal probe;
   c) endodontic probe;
   d) scaler.
5. The working length of the root canal is determined:
   a) according to the subjective feelings of the doctor;
   b) according to the patient's feelings;
   c) by X-ray with endodontic instrument;
   d) by electroodontodiagnostics.
6. Apex locator works according to the principle of:
   a) measuring AC resistance in different parts of the root canal;
   b) measuring DC resistance in different parts of the root canal.
7. How to use the apex locator correctly:
   a) one electrode is attached to the patient's lip, and the second to the file;
   b) one electrode is attached to the patient's thumb, and the second to the file.
8. Methods for determining the working length of a root canal:
   a) radiological;
   b) tabular (mathematical);
   c) ultrasonic;
   d) electrometric (apex locator);
   e) tactile.
9. Working length of the root canal:
   a) is longer than 1 mm than the radiographic length of the tooth;
   b) exactly matches the anatomical length of the tooth;
   c) is 1 mm shorter than the radiographic length of the tooth.

10. To fix the working length of the instrument and prevent the instrument from going beyond the apical opening, use:
    a) stoppers (limiters);
    b) spreader;
    c) plugger.

The answers: 1 — a, b, c; **2** — a, b, c; **3** — a; **4** — c; **5** — c; **6** — a; **7** — a; **8** — a, b, d, e; **9** — c; **10** — a.

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