WORKING LENGTH DETERMINATION

PRESENTED BY : DR. SHIKHA KANODIA

CONTENTS

- Apical periodontal sensitivity
- Paper point measurement
- Xeroradiography
- Digital Radiography
- Electronic apex locators

Other uses of Apex Locator

Conclusion

References

TERMINATION POINT WITH A VITAL PULP

With an irreversible pulpitis (vital pulp), bacteria (if present) are usually limited to the chamber. Instrumentation apically is to remove the noninfected tissue and to shape the canal. For these cases, the favorable point to terminate instrumentation and to form an apical stop appears to be 2 to 3 mm short of, rather than 0 to 2 mm from, the apex.[12,28] This principle (partial pulpectomy) was originally proposed by Davis[29] in 1922. He suggested preservation of vital pulp apically, often referred to as the apical pulp stump. Following this principle, a good success rate was obtained by Kerekes and Tronstad[28] and by Sjögren et al.[12] Therefore, for vital cases, the biologic and clinical evidence indicates it is ur

Apical terminus location

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Canals with necrotic pulp tissue with or without periradicular pathosis are treated as infected canals.[28] An approach is to evaluate the correlation between the termination point and the success rate of infected canals by using the data from only those cases with pretreatment radiolucencies. These are likely the cases with infected canals[32]; the change in size of the lesion after treatment is assessed radiographically. A definite correlation between the radiographic and histologic findings has been reported for the teeth with pretreatment apical radiolucencies only.[33] Importantly, a tooth with no apical radiolucency before treatment may actually have an apical pathosis that is not radiographically visible.[34] Therefore, information about the change in lesion size after the treatment may not be provided by the radiographs if the lesion remains invisible. Perhaps this is why no definite correlation between the radiographic and histological findings could be found for the teeth without pretreatment apical radiolucencies.[33]

The best success for treatment of teeth with necrotic pulps has been recorded when RCT was terminated at or within 2 mm of the radiographic apex (0 to 2 mm) for infected canals with visible apical pathosis. However, statistically significantly lower success was recorded

TERMINATION POINT FOR RETREATMENT

When present, the AC is the narrowest diameter of the blood supply. Apically, the canal widens and may have a richer blood supply that may allow better immune activities than in the pulp canal. However, bacteria may sometimes persist in the canal[44] and survive beyond the AC; a speculation is that these bacteria are related to RCT failures.[1] It seems that it would be preferable to clean the canal to the AF in retreatment; the downside is the possibility of overinstrumentation, which would force materials and debris into periradicular tissues.

In order to reduce the introduction of irritants into the periapex, a suggestion is to clean the coronal part of the root canal first with a step-down or crown-down sequence[45] with copious irrigation. However, instrumentation extended beyond the radiographic apex, which certainly would have its apical terminus beyond the AF, has been found to hinder apical healing significantly.[46-48] Although instrumentation to the AF is suggested for some failure cases, usually the apical stop should be created at 1 to 2 mm short of the AF to confine the instruments, irrigants, and obturants to the canal space.

- ✓ It is the point in the canal where cementum meets dentin
- ✓ Where pulp tissue end and pdl tissue begins
- ✓ It is a histological landmark,cannot be located clinically or radiographically.

CDJ

Max.central incisor:353 micron
max.lateral incisor: 292 micron
Canines 298 microns

Location and diameter

- ✓ Extension differed considerably on opposing canal walls
- ✓ 5% cases extend till same level
- ✓ Diameter of canal at cdj was also highly irregular

The endodontic line: A clinical approach
Vittorio Franco et al

The cdc junction
Ponce &Fernandez et al.

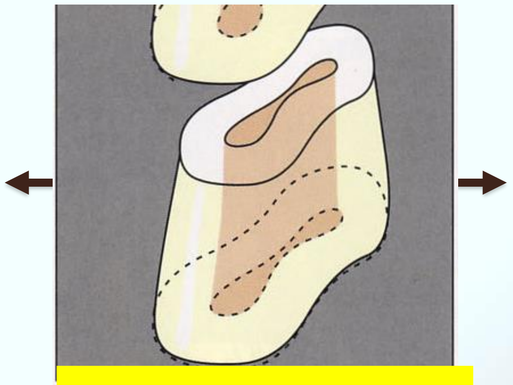
CDJ

Clinical significance

- ✓ Theoritically,cdj is the appropriate apical limit for root canal treatment.
- ✓ As at this point the point of contact between the periradicular tissues and filling material is likely to be minimal
- ✓ But ,clinically not possible to identify.

(Palmer et al. 1971, Seltzer 1988, Katz et al. 1991, Ricucci & Langeland 1998).

A narrow ribbon-shaped communication between two root canals.



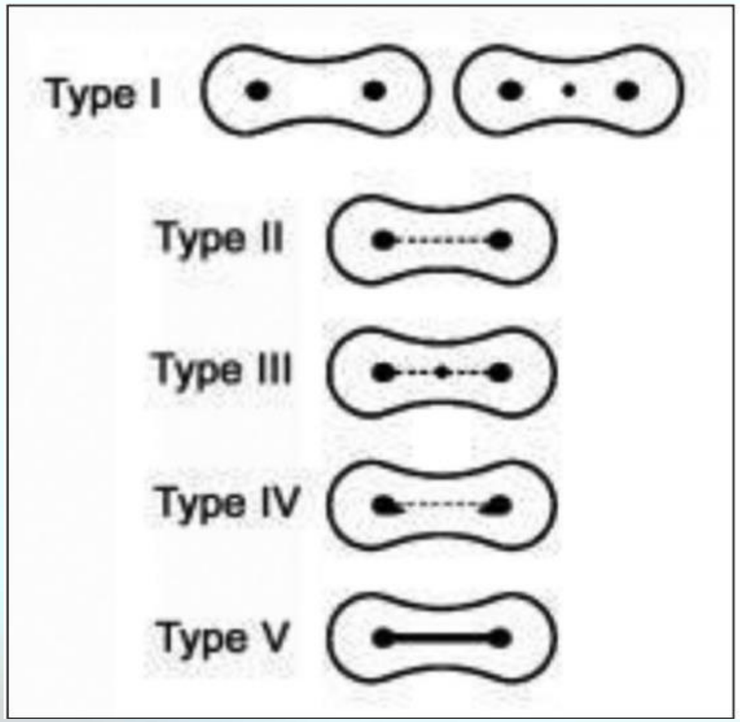
ISTHMUS

Majority :in the apical 5 mm of root canals

It may contain pulp remnants, necrotic tissues, and micro-organisms and their byproducts

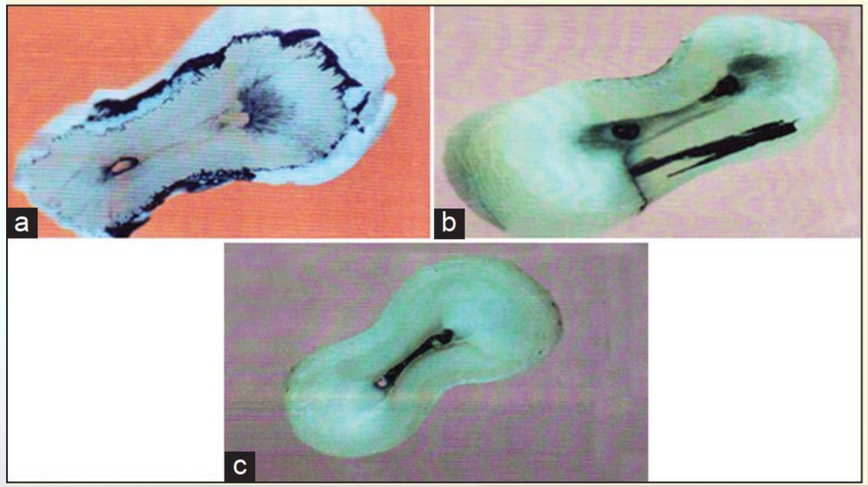
Mehrvarzfar P,et al. Evaluation of isthmus prevalence

Isthmus classifications by hsu and kim



ISTHMUS

Teixeira classification



A- No isthmus
b- Incomplete isthmus
C- complete isthmus

Dental Research Journal

Original Article

Evaluation of isthmus prevalence, location, and types in mesial roots of mandibular molars in the Iranian Population

Payman Mehrvarzfar, Nahid Mohammadzade Akhlagi, Fatemeh Khodaei, Golnaz Shojaee, Sara Shirazi

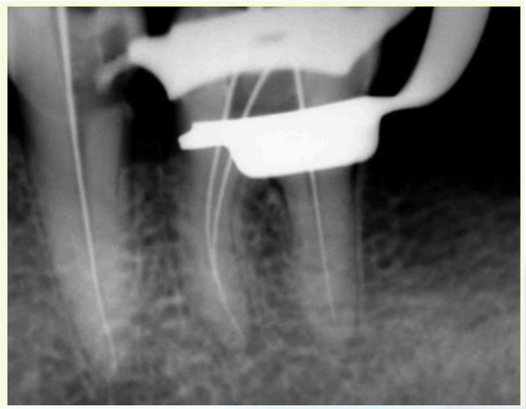
Department of Endodontics, Dental branch, Islamic Azad University, Tehran, Iran

Prevalence of isthmus type	2 mm from apex	4 mm from apex	6 mm from apex
Type I	18 (30)	7 (11.7)	5 (8.3)
Type II	6 (10)	10 (16.7)	24 (40)
Type III	3 (5)	9 (15)	5 (8.3)
Type IV	2 (3.3)	6 (10)	11 (18.3)
V Type	31 (51.7)	28 (46.8)	15 (25)
Total	60 (100)	60 (100)	60 (100)

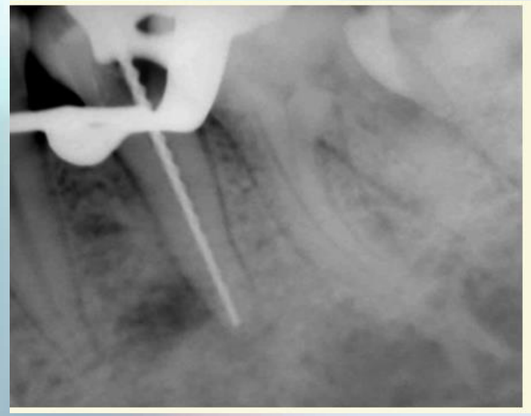
Management of complete isthmus is easier with the use of microsurgical techniques, such as the usage of a dental operating microscope and microsurgical instruments.

An unprepared isthmus in the root canal system, might contain necrotic debris and tissue remnants, which might serve as a reservoir for bacteria, leading to endodontic failure.

- The significances of this procedure are the following.



- 1. The calculation determines how far into the canal the instruments are placed and worked and thus how deeply into the tooth the tissues, debris, metabolites, end products, and other unwanted items are removed from the canal.
- 2. It will limit the depth to which the canal filling may be placed.
- 3. It will affect the degree of pain and 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, and conversely, if calculated incorrectly may doom the treatment to failure



DIFFERENT METHODS OF WORKING LENGTH DETERMINATION

Radiographic methods

- Grossman formula
- Ingle's method
- Weine's method
- Kuttler's method
- • Radiographic grid
- Endometric probe
- Direct digital radiography
- Xeroradiography
- Subtraction radiography

Non radiographic methods

- Electronic apex locator
- Digital tactile sense
- Apical periodontal sensitivity
- Paper point method

SCHOOL OF THOUGHT

Locating the CDJ

Radiographic apex

DETERMINING FACTORS

ADVANTAGES

Less chances of under obturation

DISADVANTAGES

- Decrease in success rate (Strinberg , Seltzer et al)
- Post operative pain (Davis et al)
- Delay in healing
- undesirable shape – a tear drop

Endodontic therapy by franklin weine'6thED

Knowledge of average working length

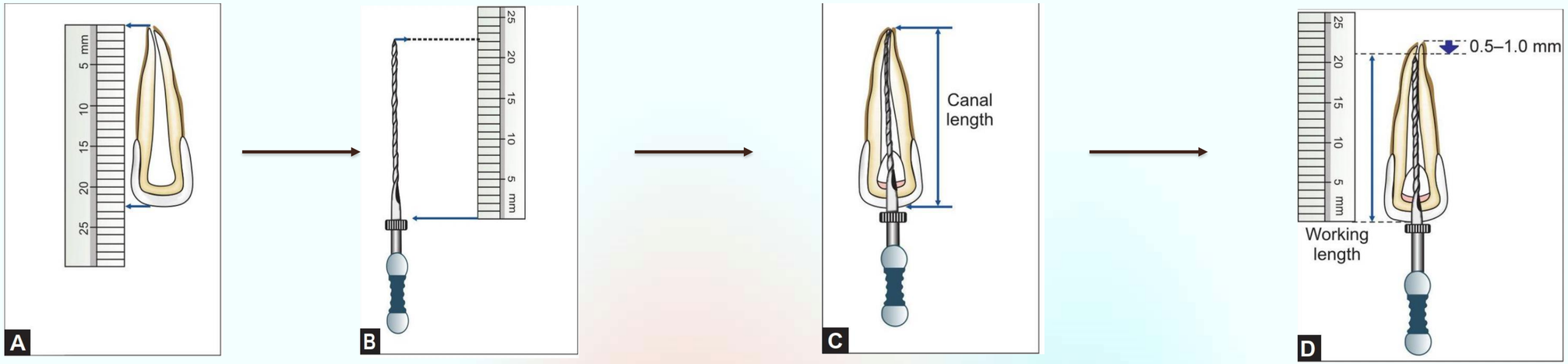
Silicone stopper

INGLES RADIOGRAPHIC METHOD

Instrument precurving

Stable occlusal reference

- SILICONE STOPPERS
- TEAR DROP/ROUND
- PERPENDICULAR

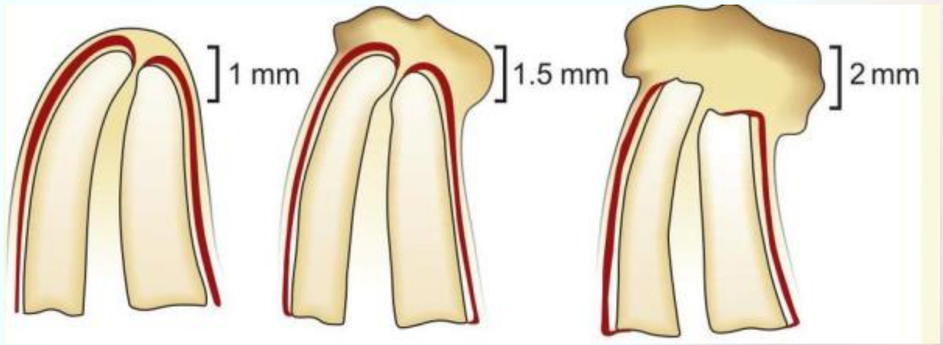


Short on radiography by more than 1 mm

Beyond the radiographic apex

TIP OF INSTRUMENT IS 0.5-1 MM OF RADIOGRAPHIC APEX

WL established



No periapical resoption

Weine's Modification

Periapical bone resoption

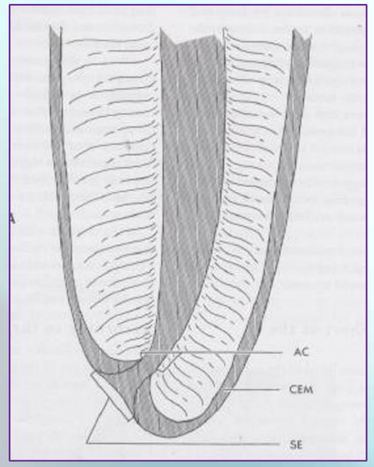
Bone + root resoption

ACCORDING TO THE STUDIES OF KUTTLER

Average distance b/w minor & major diameters were

18-35yrs – 0.524 mm

35 & older age – 0.659 mm



ACCORDING TO THE STUDIES OF KUTTLER

Prepare the access cavity

↓

Locate major and minor diameter on radiograph

↓

Estimate length of roots

If

- ✓ The tooth is longer than average:use 95th percentile value
- ✓ Shorter than average:use 5th percentile value
- ✓ Average:use average value

Estimate the width of the canal(s) on the radiographs

↓

place the file into the access cavity and take an initial radiograph.

↓

too long or too short by more than 1 mm from the minor diameter(interpolation)

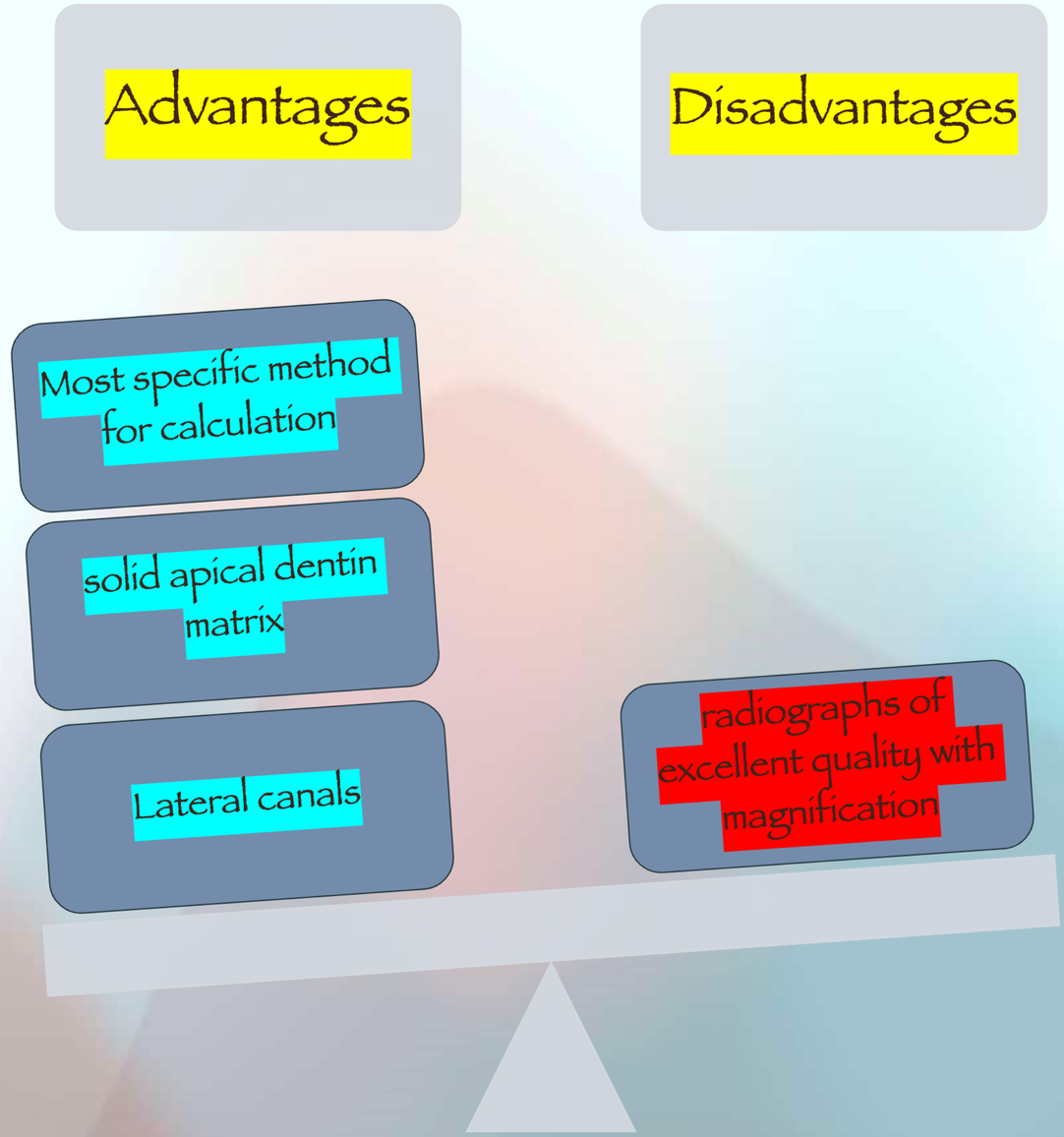
↓

file reaches the major diameter(subtract 0.5/0.67mm)

KUTTLER'S METHOD

Tooth	Total Length	Crown Length	Root Length
Maxillary central incisor	A = 23.0	10.5	12.5
	L = 28.0	12.0	16.0
	S = 18.0	8.0	8.0
Maxillary lateral incisor	A = 22.5	9.0	13.5
	L = 27.0	10.5	16.5
	S = 17.0	8.0	8.0
Maxillary cuspid	A = 27.0	9.5	16.5
	L = 32.0	12.0	20.5
	S = 20.0	8.0	11.0
Mandibular incisor	A = 21.0	9.0	12.0
	L = 25.0	10.5	14.5
	S = 16.0	7.0	9.0
Mandibular cuspid	A = 24.0	10.0	15.0
	L = 30.5	12.0	20.5
	S = 20.0	8.5	11.5

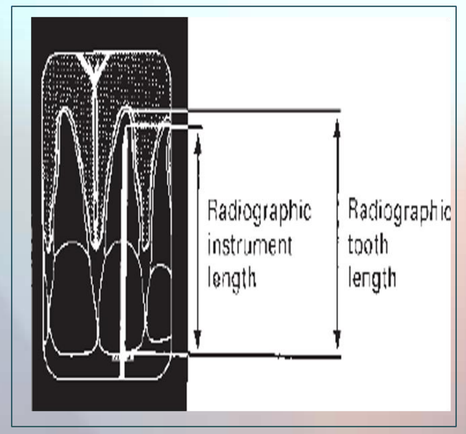
Tooth	Total Length	Crown Length	Root Length
Maxillary first bicuspid	A = 21.0	8.5	12.5
	L = 24.0	10.0	14.5
	S = 17.5	7.0	10.0
Maxillary second bicuspid	A = 21.0	8.5	12.5
	L = 25.0	10.5	15.0
	S = 17.0	7.0	9.5
Mandibular first bicuspid	A = 21.5	7.5	14.0
	L = 25.0	9.0	17.0
	S = 17.0	6.5	11.5
Mandibular second bicuspid	A = 22.0	8.0	14.0
	L = 25.0	10.0	17.0
	S = 17.0	6.0	11.5


Advantages
Disadvantages
Most specific method for calculation
solid apical dentin matrix
Lateral canals
radiographs of excellent quality with magnification

GROSSMAN METHOD/MATHEMATICAL METHOD OF WORKING LENGTH DETERMINATION

$$\frac{\text{Actual length of the tooth}}{\text{Actual length of the instrument}} = \frac{\text{Apparent length of tooth in radiograph}}{\text{Apparent length of instrument in radiograph}}$$

$$\text{Actual length of tooth} = \frac{\text{Actual length of the instrument} \times \text{Apparent length of tooth in radiograph}}{\text{Apparent length of instrument in radiograph}}$$

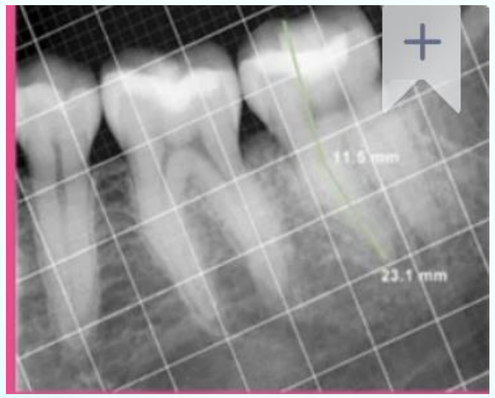


Disadvantages

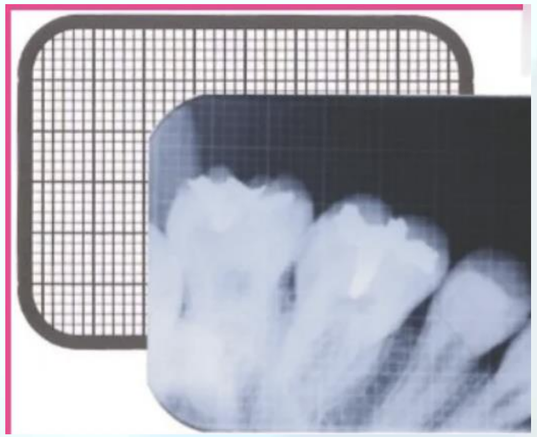
Wrong readings can occur because of:

- Variations in angles of radiograph
- Curved roots
- S-shaped, double curvature roots

Everett and Fixott



RADIOGRAPHIC GRID

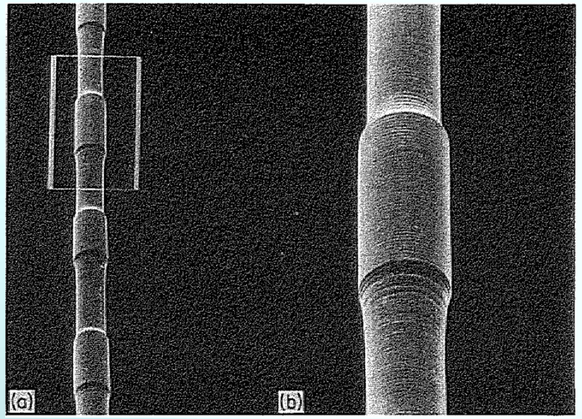


Bent radiograph

Overcomes need for calculation

Endometric Probe

- The Endometric Probe is an endodontic instrument, designed specifically to help improve the accuracy and reliability of root canal length estimation. The probe is calibrated by a series of constrictions 1 mm in length which occur at regular 1 mm intervals along the instrument



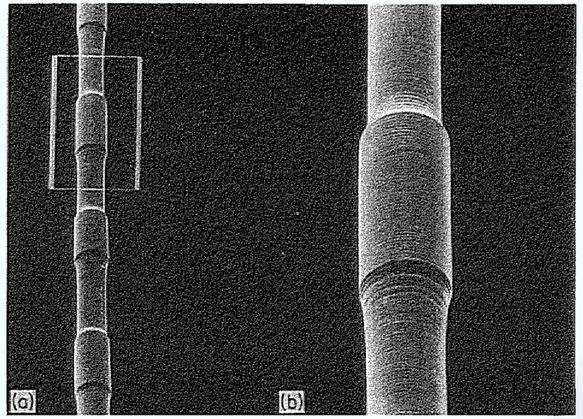
✓ Graduations on diagnostic file which are visible on radiograph

❖ Smallest file size to be used is no 25

International Endodontic Journal (1987) 20, 25–29

An evaluation of the Endometric Probe in root canal length estimation

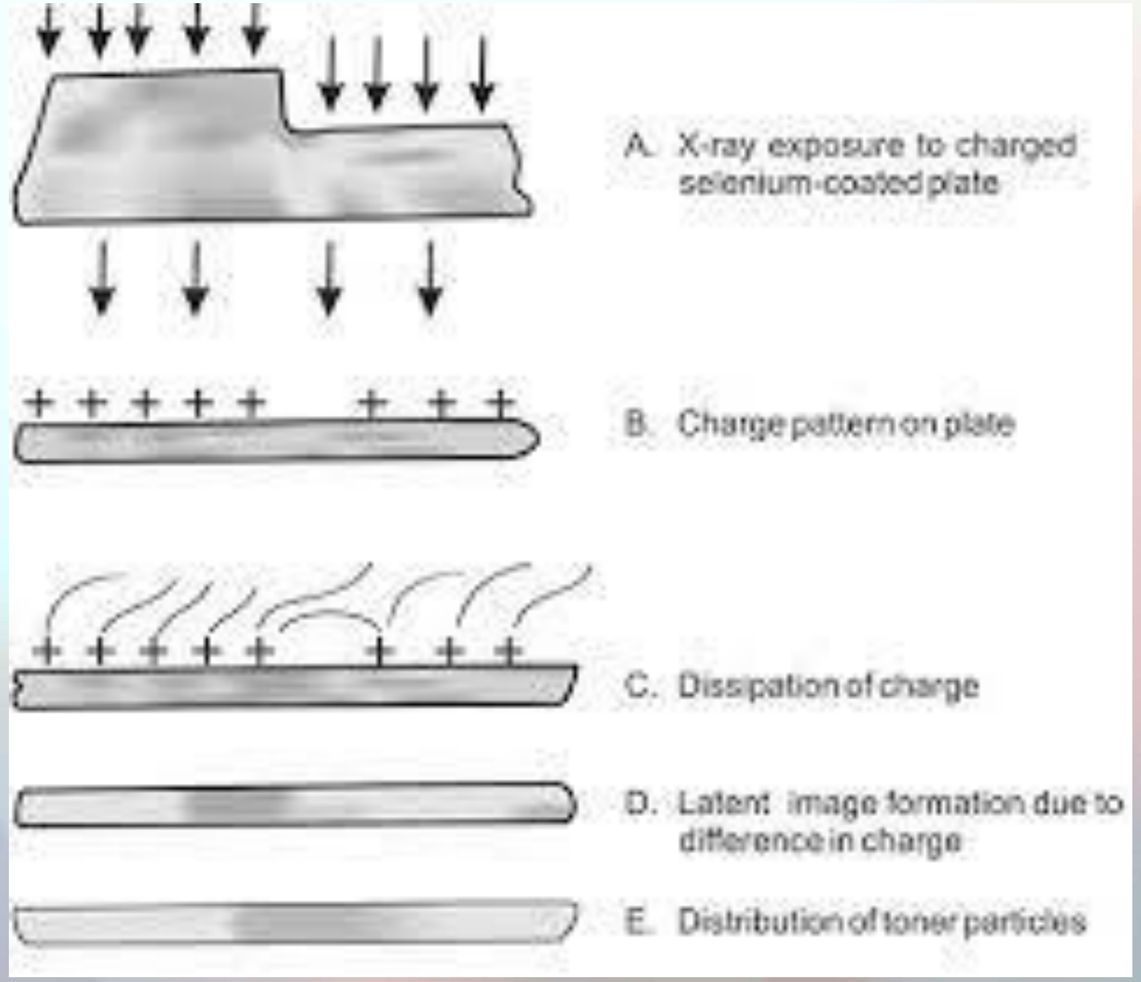
P. M. H. DUMMER & J. M. LEWIS *Department of Conservative Dentistry, University of Wales College of Medicine, Dental School, Cardiff*



Radiographic image	K-file	Endometric Probe
Undistorted	0.78 ± 0.12*	0.49 ± 0.07
Elongated	0.86 ± 0.21*	0.56 ± 0.10
Shortened	0.84 ± 0.19*	0.60 ± 0.09
Overall	0.83 ± 0.04†	0.55 ± 0.06

ISCREPENCY WITH DIFFERENT RADIOGRAPHIC PROJECTIONS

Xeroradiography



- Advantages
- 'Edge enhancement' & good detail
- Both positive and negative prints together
- Improves visualization of files and canals
- More sensitive than conventional films

Disadvantages

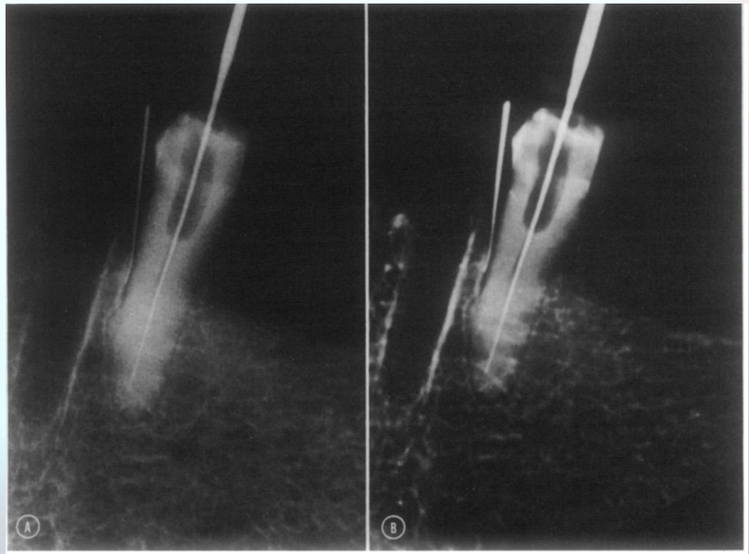
- Discomfort to the patient
- Exposure time varies according to thickness of the plate

DM brebner · 1973 an introduction to xeroradiography

An evaluation of xeroradiographs and radiographs in length determination in endodontics

R. A. Barkhordar, D.M.D., R. J. Nicholson, D.D.S.,** N. T. Nguyen,*** D.D.S., and J. Abbasi,**** San Francisco, Calif.*

SCHOOL OF DENTISTRY, UNIVERSITY OF CALIFORNIA AT SAN FRANCISCO



g. 3. A, Conventional radiograph showing metal instrument within root canal system. **B,** Xeroradio-aph more accurately demonstrating position of endodontic file within root canal system.

Entity	*3-optimal* $\left(\frac{X}{R}\right)$	*2-adequate* $\left(\frac{X}{R}\right)$	*1-poor* $\left(\frac{X}{R}\right)$	*0-unacceptable* $\left(\frac{X}{R}\right)$
Working length determination	64.07%	26.92%	6.38%	2.53%
	32.03%	46.15%	17.92%	3.84%
Clarity of root apex	70.50%	25.64%	3.84%	0
	41.02%	46.15%	11.53%	1.28%
Periapical bone detail	69.32%	28.20%	2.56%	0
	38.46%	60.25%	1.28%	0
Periodontal ligament visualization	65.38%	32.05%	2.56%	0
	41.02%	56.41%	2.56%	0

DIGITAL RADIOGRAPHY

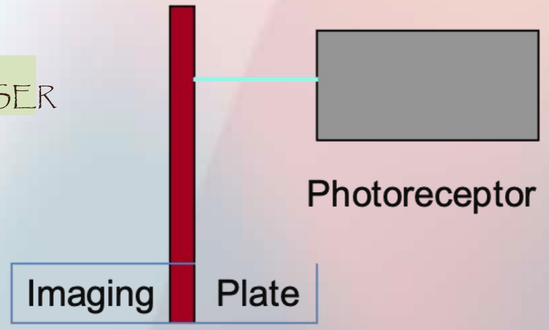
*The **direct digital systems use a solid-state sensor** such as a charge coupled device (C**CD)**. These systems have a cable that connects the sensor to the computer and in turn to the screen monitor*

- The **storage phosphor systems use a photo-stimulable** phosphor plate that stores the latent image in the phosphor for subsequent readout by an extraoral laser scanner

PHOTOSTIMUABLE PHOSPHOR PLATES

First introduced in 1981 by the Fuji Corporation (Tokyo, Japan).

HELIUM-NEON LASER



PHOTOSTIMUABLE PHOSPHOR PLATES

PSP consists of a polyester base coated with a crystalline halide emulsion {Europium-activated barium fluoro halide compound }

Stored energy

Blue fluorescent light

Emitted light is captured & intensified by a photomultiplier tube

Converted into digital data.

PHOTOSTIMULABLE PHOSPHOR PLATES

ADVANTAGES

- The smaller size and lack of a cord may make intraoral placement of phosphor plates easier than placement of direct sensors.
- Phosphor plates are somewhat flexible.
- Phosphor plates can potentially be reused hundreds of times
- It is less expensive

DISADVANTAGES

- Time required to scan (with bright light)
- Less resolution

RADIOVISUOGRAPH

RVG was Ist introduced commercially in 1987 by Mouyen et al

- The Radio – conventional X ray generator with microprocessor controlled timer together with an intra – oral sensor composed of a rare earth in couple (CCD) through an array of optical fibers
- Signal from the CCD is transmitted through a long flexible cable to the display-processing unit ‘Visio’ part of equipment .
- The ‘Graphy’ part of the image consists of a digital mass storage unit connected to a thermal printer

RADIOVISUOGRAPHY

- Image enhancement
- Aids in diagnosis of root canals with accuracy
- Edge enhancement –enchances the edges b/w the adjacent regions

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ISSN 1546-9239

Introducing Radio-Opaque Radio-Lucent Graduated Root Canal Length Indicating Cones (GRCLIC) in Endodontics

Mohammad Rashid Shahidi Bonjar
School of Dentistry, University of Medical Sciences, Kerman, Iran

Radio Opaque-Radiolucent *Graduated Root-Canal Length Indicating Cone* (GRCLIC) in position.

totally accurate or infallible. Because we cannot directly visualize the ends of root canals *in vivo*, length determination requires careful clinical assessment. Application of GRCLIC in conventional radiography in WL determination highly improves the accuracy of measurements while it decreases treatment faults such as: 1) over or under filing and obturation, 2) diagnostic radiographs produce two dimensional images of a three dimensional object, 3) technical errors of radiographic imaging of root canal such as low or high vertical X-ray cone angle, 4) radiographic magnification of the diverging central X-ray beam, 5) dilacerations / root curvatures and 6) film bending and distortion during exposure, leading to images as shortened or elongated roots (Fig. 4). In all of these cases, WL would not be mismeasured

APEX LOCATORS

Electronic apex locators use an electrical circuit, traversing through the endodontic canal and the patient's oral tissues, to determine the location of the apical foramen

EAL + Radiographs = greater accuracy of working length control(Mc Donald 1992,Patter & Mc Donald 1996)

Apex locator (ERCLMDs)

Adjunct to radiographs

How to measure the root canal by using EAL?

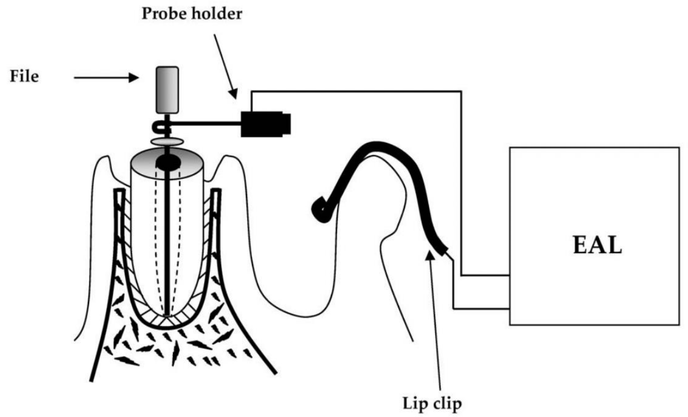
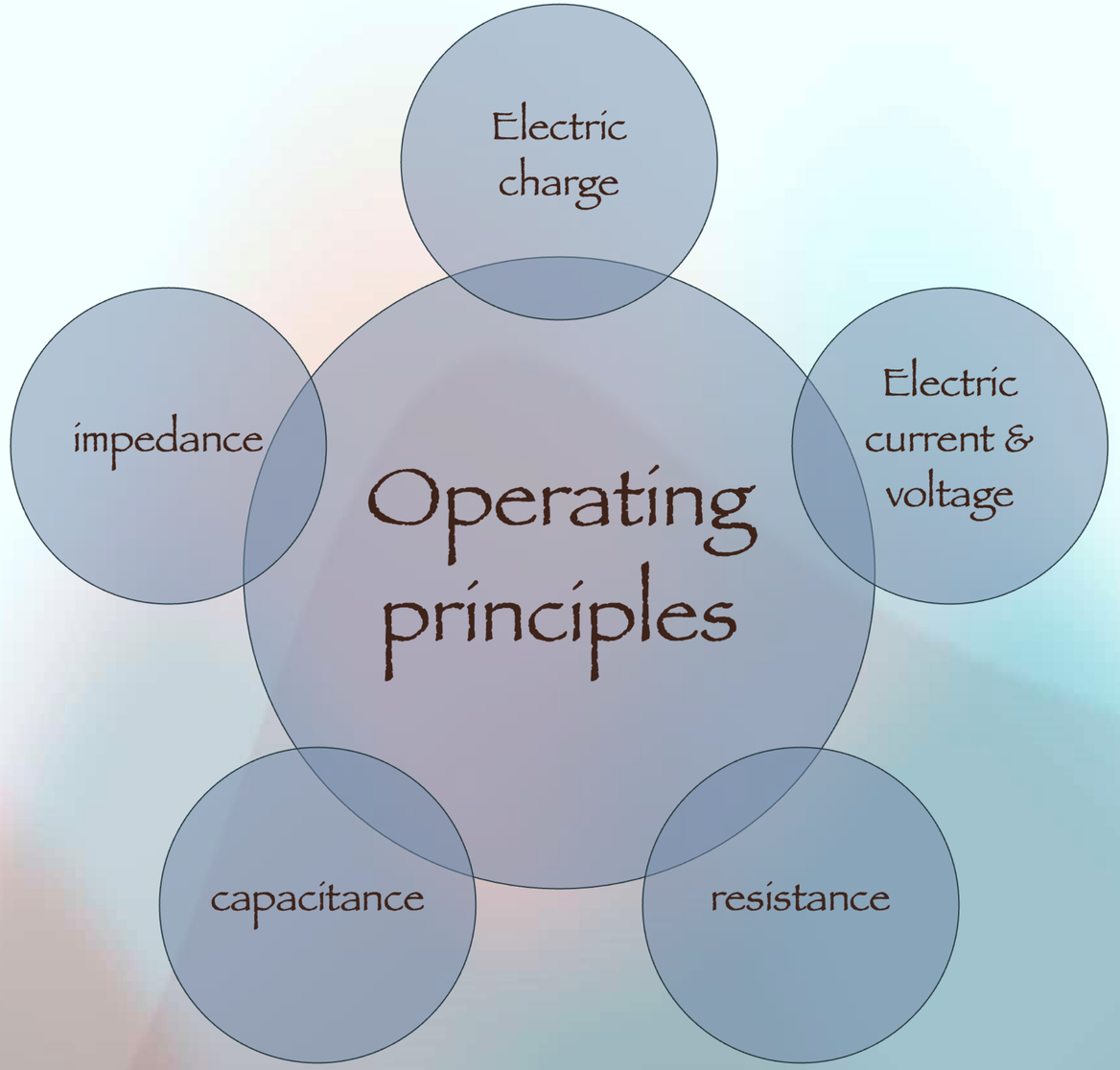


Fig. 3. Typical circuit for electronic determination of working length

M. H. Nekoofar1,2, M. M. Ghandi3, S. J. Hayes2 & P. M. H. Dummer2



M. H. Nekoofar1,2, M. M. Ghandi3, S. J. Hayes2 & P. M. H. Dummer2

ELECTRICAL CHARGE, VOLTAGE AND CURRENT

Electrical charge (Q)

Positive Negative

)

- A certain amount of energy must be used in the form of work to overcome the forces and move the charges a given distance apart.
- All opposite charges possess a certain potential energy because of theseparation between them.
- The difference in potential energy of the charges is voltage V - volt.
- Voltage provides energy to electrons or ions that allows them to move through a circuit.
- This movement is electrical current characterized by 1 ampere, which results in work being done in an electric circuit.

RESISTANCE

- When there is a current of free electrons in a material the electrons occasionally collide with atoms and lose some energy which restrict their movement.
- Denoted by R

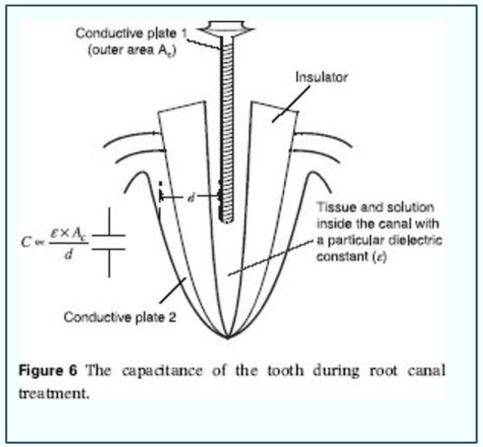


Figure 6 The capacitance of the tooth during root canal treatment.

CAPACITOR

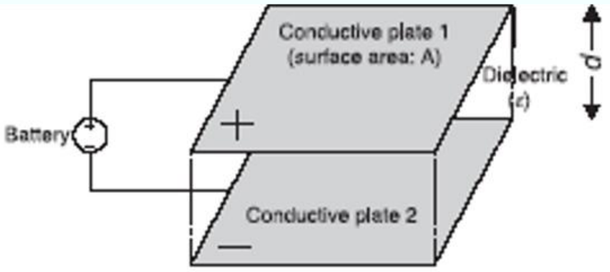


Figure 4 A simple capacitor connected to a battery (DC voltage source).

A structure of two conductive materials with an insulator between them forms an electrical device called a capacitor.

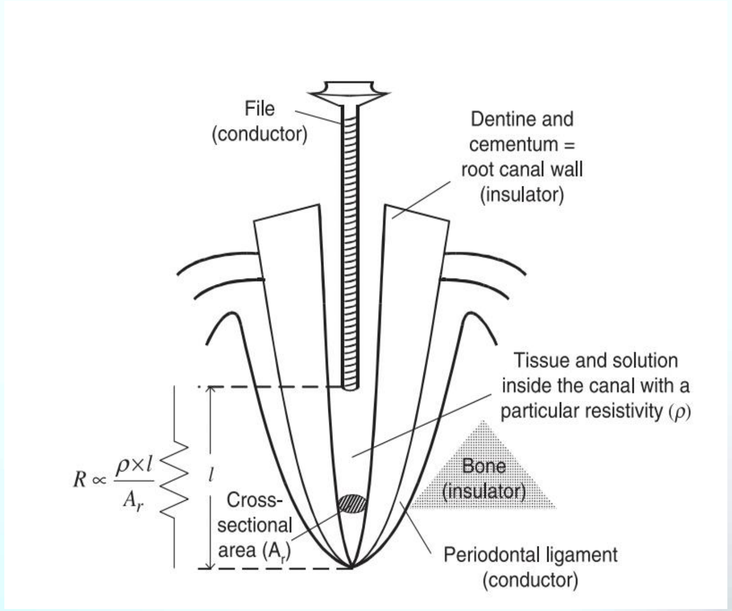
The amount of charge that a capacitor can store will determine its capacitance

$$C = \frac{\epsilon \text{ X } A}{d}$$

IMPEDANCE AND ITS MEASUREMENT

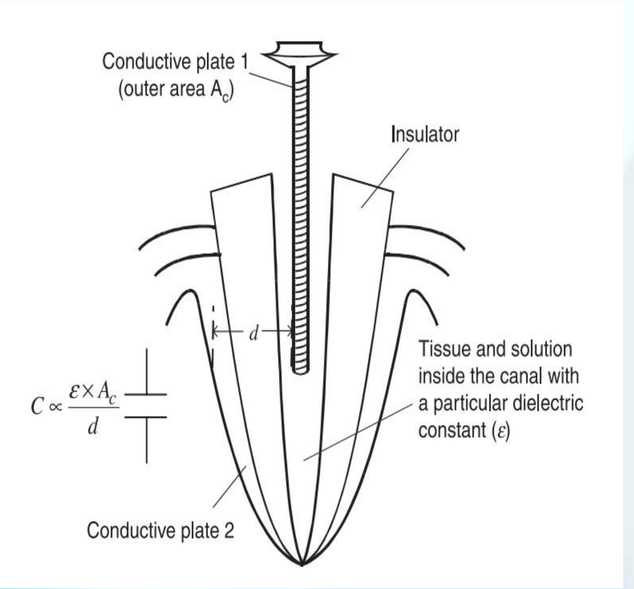
In a circuit that has both capacitors and resistors, the total amount of opposition to an alternating current is called impedance which is represented by Z.

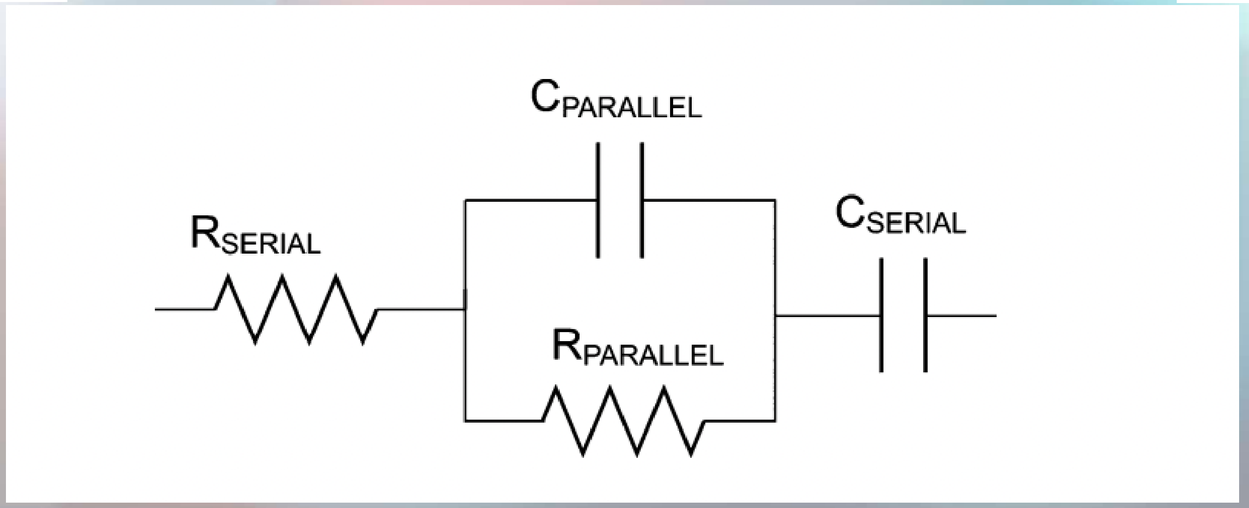
$V = I Z$ or $I = V / Z$ or $Z = V / I$



Electrical feature of tooth structure

Capacitance of tooth





CLASSIFICATION

Ist Generation Electronic Apex Locator

II ndGeneration Electronic Apex Locator

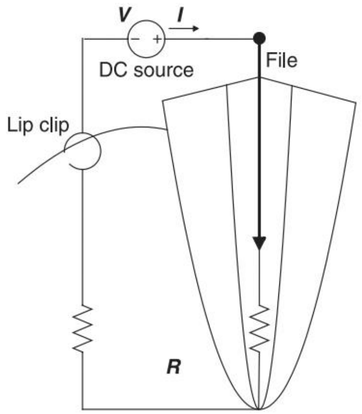
III rdGeneration Electronic Apex Locator

IV thGeneration Electronic Apex Locator

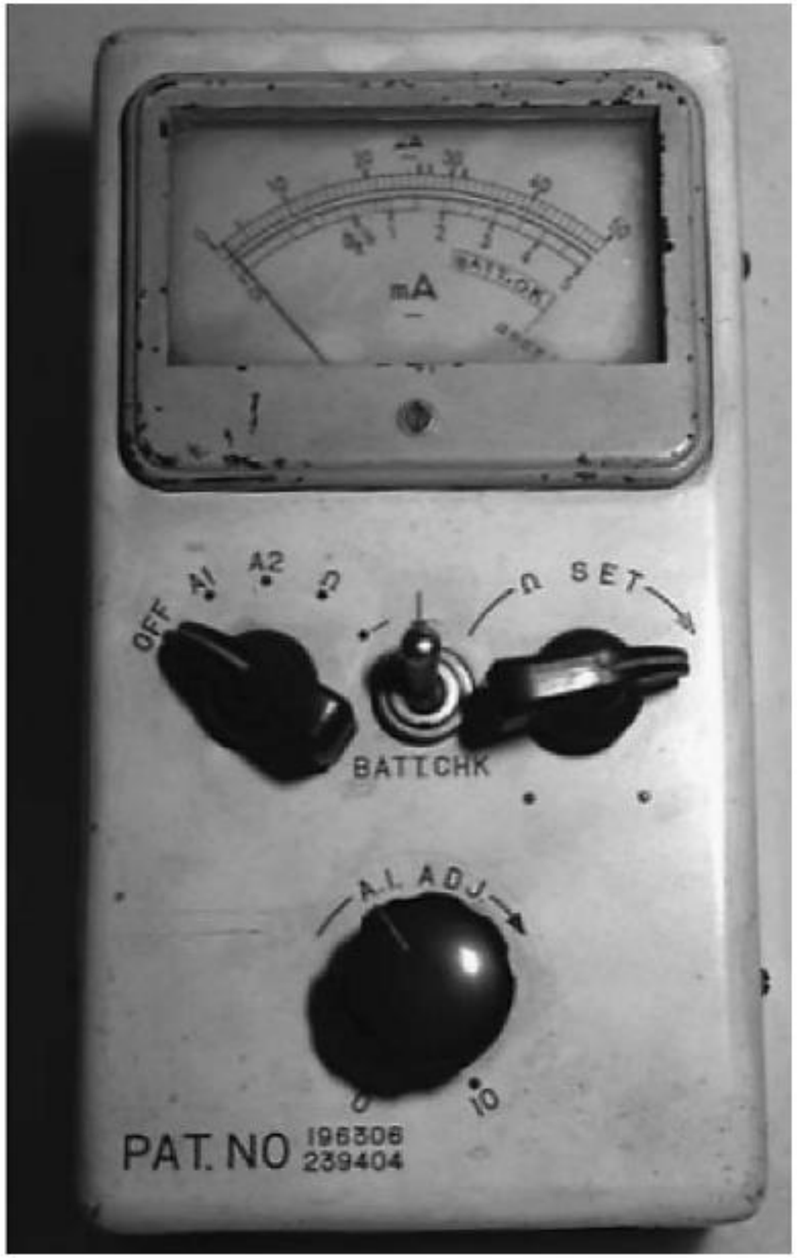
Vth Generation Electronic Apex Locator

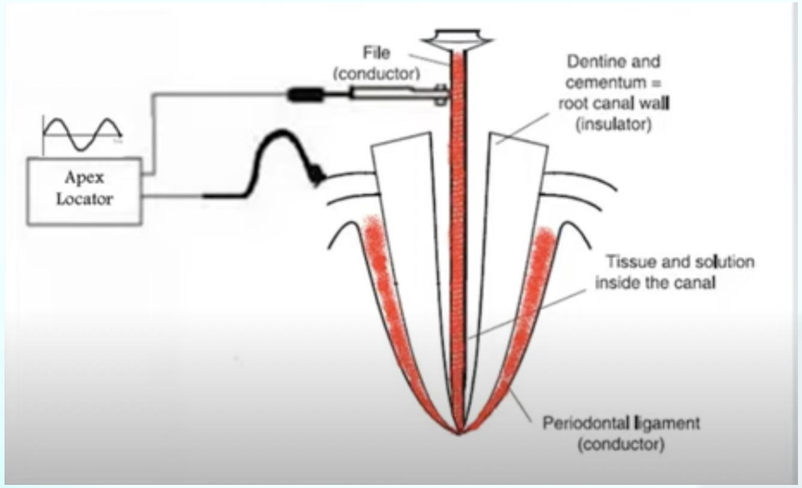
VIth Generation Electronic Apex Locator

Grossman 13th ed



$$R = \frac{V}{I}$$





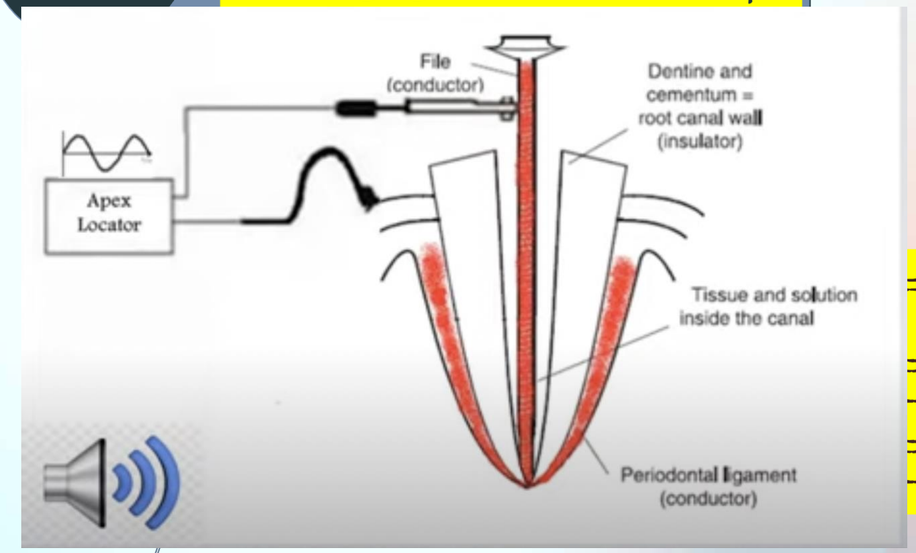
- strong elec
- excessive
- pus
- pulp tissu

ile tip touches the electro conductive
olution (electrolyte) - the DC
oltage polarizes the tissues and
aries its resistivity -
ncorrectly indicates that the minor
pical foramen has been reached

g: Endometer

Low frequency

Omm & gingival sulcus=omm & pdl



Disadvantage:individual calibration was required

Frequency based
EALs (2nd generation
EALs)

high frequency upto 400

Difficulty to use in narrow canals

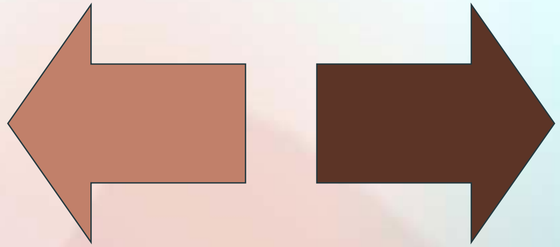
Canal and tissues have capacitive characteristics as well as resistive characteristics.

Two frequencies, impedance difference ERCLMDs

Developed by Yamaoka

$$\text{Diff} = Z(f_H) - Z(f_L)$$

In the coronal portion of the root canal system, the device must be calibrated to eliminate any effect of the dielectric material inside the canal.



Two frequencies, impedance ratio (Quotient) ERCLMDs

The impedance ,measured at each frequency and the position of the file is determined from the ratio between these two impedances

$$\text{Ratio} = \frac{Z(f_H)}{Z(f_L)}$$

Eg :root zx

Root zx (3GEALs)

Kobayashi & Suda

- ✓ Dual-fr
- ✓ The ele
- ✓ Measur the canal
- ✓ Microp impedar
- ✓ The qu lay meter p the canal

Reference	Study type	Sample (N)	Accuracy
Czerw			% (±0.5mm)–AF
Katz et			% (±0.5mm)–AF
Shabaha			% (±0.5mm)–AF
White e			% (±0.5mm)–AC
Vajrabh			% (±0.5mm)–AF
Pagavir			)–AC, 100%(±1.0mm)–AF
Dunlap			% (±0.5mm)–AC
Ibarrola			% (±0.5mm)–AC
Ounsi &			% (±0.5mm)–AF
Weiger			% (±0.5mm)–AC
Mears &			% (±0.5mm)–AF
Welk et			% (±0.5mm)–AC
Goldbe			)–AC, 100% (±1.0mm)–AF
Tselnik et al.(2005)	*in vivo*	27	75% (±0.5mm)–AC
Plotino et al.(2006)	*in vitro*	37	97.4%(±0.5mm)–AF

Combination of Apex Locator with Endodontic Handpiece

The Root ZX has been combined with a handpiece to measure canal length when a rotary file is used[74]. This is marked as the Tri Auto ZX (J. Morita Co., Kyoto, Japan). The handpiece uses nickel-titanium rotary instruments that rotate at 240 to 280 rpm[74]. Kobayashi et al. suggested that "to get the best results, it may be necessary to use some hand instrumentation" in combination with the Tri Auto ZX, depending on the difficulty and morphology of the root canal being treated[74]. The Tri Auto ZX has a reported accuracy similar to the Root ZX of 95%[75]. Alves et al. evaluated *in vitro* the capacity of the Tri Auto ZX to locate the AF following removal

A. K. EBRAHIM, R. WADACHI and H. SUDA

MULTIFREQUENCY ERCLMDS(4th generation)

Measure the impedance characteristics using more than two frequencies.

Endo Analyzer 8005 & AFA Apex Finder 7005 - 5 different frequencies have been used and the device measures both components (phase and amplitude) of impedance at each frequency.

Utilize the resistance and capacitance measurements and thereafter compare them with a database to measure the distance of the file to the apex of the canal.

The RMS (Root Mean Square) level of the signal is measured, rather than its amplitude or phase

Fifth Generation Electronic Apex Locators (5th GEALs) (Dual frequency ratio type)

- Comparison of the data taken from the electrical characteristic of the canal and additional mathematical processing.
- It measures the capacitance and resistance of the circuit separately. It is supplied by diagnostic table that includes statistic of the file.
- The built in pulp tester can be used to access tooth vitality
- .Disadvantage: operating in dry canals

Sixth Generation Electronic Apex Locators (6th GEALs)

Adaptive Apex Locators

- A major advantage of adaptive apex locator is eliminating necessity of drying and moistening of the canal. Adaptive apex locators continuously define humidity of the canal and immediately adapts to dry or wet canal

OTHER USES FOR APEX LOCATORS

Determination of location of root perforations by electronic apex locators

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EAL	Group	Saline solution*		NaOCl		Dry*	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
						17	(0.07)
						19	(0.15)
						42	(0.42)
						37	(0.39)

Accuracy of the Justy II Apex locator in determining working length in simulated horizontal and vertical fractures

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In horizontal fractures, the EAL was accurate. However, in simulated vertical fractures, the EAL was unreliable in determining the position of the defect. The EAL identified the apex consistently shorter than the file.

compared with a distilled water–filled canal [41] in an in vitro saline–gelatin model, the Root ZX showed no difference between the distilled water and dry canal.

To determine whether the concentration of sodium hypochlorite influenced the accuracy of the Root ZX, Meares and Steiman [42] flushed the canal with 2.125% and 5.25% sodium hypochlorite and the measurements from the in vitro model then were compared with the actual canal lengths. No significant differences were found between the experimental groups. The authors [42] suggested that the Root ZX was not adversely affected by the presence of sodium hypochlorite.

In contrast, there is still a concern as to whether high electroconductive irrigants such as blood, saline, a local anesthetic solution, irrigant fluids, and

dependent EALs is that it operates accurately, even under different wet canal conditions. According to recent publications [34,42,57], the accuracy of frequency-dependent EALs is much higher than that of traditional-type EALs (simple-resistance type or impedance type). A number of experiments were conducted using both in in vivo and in vitro models (Table 1). Most of the EAL measurements were compared with the actual tooth length.

Accuracy of frequency-dependent EALs in different electrolytes

A major advantage of frequency-dependent EALs is that they operate even with a high electroconducting irrigant such as sodium hypochlorite. The operation is based on the principle of the relative difference or a quotient of two or more impedances generated at each different frequency. Although

minimized before accepting apex rea

- Canal shape, Lack of patency, the accumulation of dentine debris and can affect accurate working length determination with electronic apex locators.

- Electronic apex locators have the potential to interfere with cardiac pacemakers

Mode of working of root zx

- File is inserted until the meter reads 0.5
- File is then advanced with a slow clockwise turn until apex.
- Turn counterclockwise until 0.5 and measurement is read

foramen deviated from the main axis. The clinical accuracy was 82.75% with a tolerance level of ±0.5 mm when the measurements were read at the APEX mark. In 28 out of 29 examined teeth, the file tip protruded beyond the apical foramen with a range between 0.12 mm and 0.85 mm. The authors of this study [25] recommended the withdrawal of the instrument by approximately 0.5 to 1 mm to avoid overpreparation.

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Effect of resorption on the accuracy of EAL

The use of EALs in apical resorption is under question because of the possible destruction of the apical constricture and the loss of the surrounding periodontal tissue. Goldberg et al [39] conducted an experiment to evaluate the accuracy of the Root ZX apex locator in determining the working length in teeth with 50 simulated apical root resorptions. The measurements were accurate in 62.7% of cases with a ±0.5-mm clinical tolerance when compared with direct visual measurements. The authors [39] also reported that there were differences between the operator's measurement abilities, suggesting

Common problems with apex locator

Unstable electronic signals

An unstable electronic signal with rapid wandering signs is the most frequent malfunction of an EAL and occurs most frequently when the file touches the metallic restorations or when there is a cervical leak through the subgingival caries. Removing the metallic restoration or simply blowing air onto the wet chamber usually solves this problem.

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abruptly as it reaches the apical foramen, which makes it very difficult to locate the apical foramen precisely. This mostly occurs with a very dry canal. When the file tip is at the extremely dried point, there is little or no electric contact, even at higher frequencies. As soon as it meets with the apical tissue, a sudden circuit breaks out, which brings the signal to the APEX mark. When this occurs, gentle irrigation of the canal will reiterate the normal operation of the unit. When an EAL is used in dry conditions, such as for the final working-length verification immediately before the obturation, the operator must judge carefully the appropriate position from

3) Apex sign from the begining

At times, the signal reaches the APEX mark far before the file enters the supposed foramen area. The cause of this phenomenon is too much electrolyte in the canal. This phenomenon occurs most often with extreme bleeding and actively draining pus or exudates from the canal. When this happens, the canal should be irrigated gently with sodium hypochlorite or saline until the drainage becomes reasonably controlled. The canal may need to be blot dried in some cases.

How to tackle?

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Digital Tactile Sense

. In this clinician may see an increase in resistance as file reaches the apical 2 to 3 mm.

Advantages

- Time saving
- No radiation exposure.

Disadvantages

- Does not always provide the accurate readings
- In case of narrow canals, one may feel increased resistance as file approaches apical 2 to 3 mm
- In case of teeth with immature apex, Instrument can go periapically.

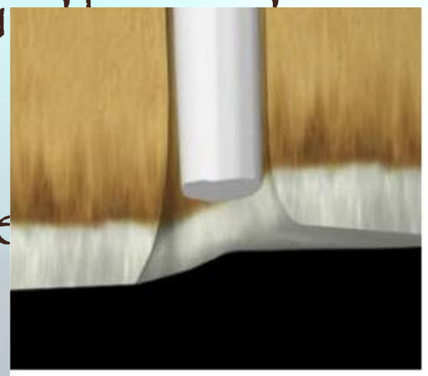
. SEIDBERG ET AL REPORTED THAT ACCURACY IS ONLY 64% WITH TACTILE SENCE

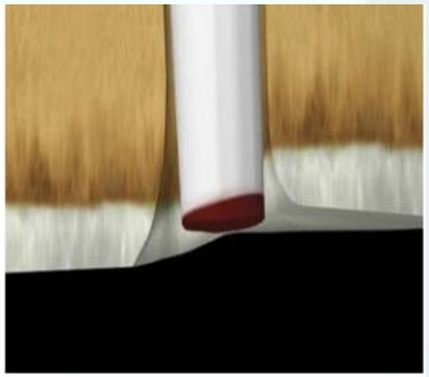
Periodontal Sensitivity Test

- This method is based on patient's response to pain
- But this method does not always provide the accurate readings
- In cases of canal with necrotic pulp, instrument can pass beyond apical constriction and in case of vital or inflamed pulp, pain may occur several mm before periapex is crossed by the instrument.

Paper Point Measurement Method

- In this method, paper point is gently passed i
  estimate the working length
- It is most reliable in cases of open apex where
  lost because of perforation or resorption
- Moisture of blood present on apical part of paper point indicates that paper point has passed beyond estimated working length
- It is used as supplementary method





Paper Point Measurement Method

Evaluating the paper point technique for locating the apical foramen after canal preparation

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UNIVERSITY OF NORTH CAROLINA AND UNIVERSITY OF IOWA

Table 1. Accuracy of paper point technique after incomplete instrumentation

Distance from cemented file tip to apical foramen (mm)	*Vital and necrotic pulps, n (%)*	*Vital pulps only, n (%)*
≥−1 to <−0.5	5 (7.0)	4 (6.6)
≥−0.5 to <−0.25	15 (21.1)	12 (19.7)
≥−0.25 to <0.0	25 (35.2)	23 (37.7)
= 0.0	2 (2.8)	2 (3.3)
>0.0 to <0.25	12 (17.0)	11 (18.0)
≥0.25 to <0.5	8 (11.3)	6 (9.8)
≥0.5 to <0.75	2 (2.8)	2 (3.3)
≥0.75 to <1	1 (1.4)	0 (0.0)
≥1 to <1.25	1 (1.4)	1 (1.6)
	71 (100.0)	61 (100.0)

Negative distance indicates that reading was short of (coronal to) root canal apical foramen.

CONCLUSION

In this study, PPT was found to be suitable for estimating the location of AF in relatively straight patent canals, because its performance was similar to current clinically acceptable standards of estimating AF location. To improve generalization, further research of PPT in canals with greater curvature, and with more varied pulpal and periapical diagnoses, is warranted.

CONCLUSION

- Modern electronic apex locator has played an excellent role in determining the working length which indirectly has an impact on the treatment success. EALs has an accuracy greater compared to others and it can also be used at angles where radiograph won't be able to be play the role.

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