Magnification assisted endodontics

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Endodontics

- tactile sensitivity
- mental imaging
- radiographs
- electronic apex locators

MAGNIFICATION

see more & see well

The limits of human vision

- resolution: the ability of an optical system to make clear and distinguishable 2 separate entities
- the resolving power of the unaided human eye is 0.2 mm: most people who view 2 points closer than 0.2 mm will see only 1 point

On the relative size of things

- clinically, most dental practitioners will not be able to see an open margin smaller than 0.2 mm
- the film thickness of most crown and bridge cements is 25 µm (0.025 mm)
- cell size is measured in microns, a single bacterial cell is about 1 µm in diameter (10^{-3} mm)
- size of macromolecules (e.g., bacterial toxins) are measured in nanometers (10^{-6} mm)

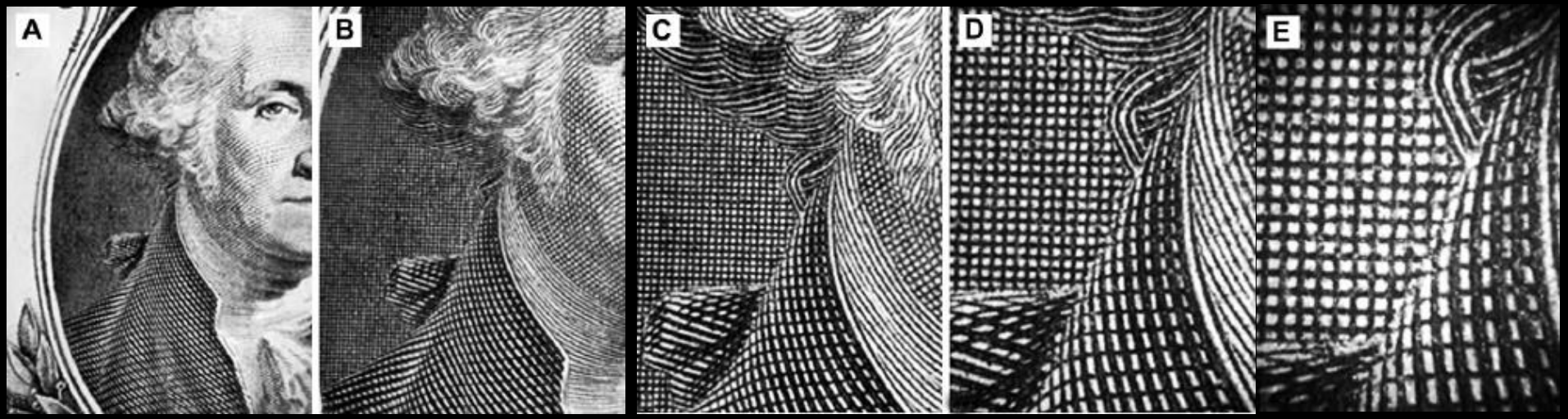
Magnification →precision dentistry

- dentists routinely perform procedures requiring resolution well beyond the 0.2 mm limit of human sight

A dollar bill without magnification

The lines that make George Washington's face are 0.2 mm apart.

Different magnifications of a dollar bill as seen through an OM



3x 5x 8x 10x 18x

Dentists can increase their resolving ability by simply moving closer to the object of observation.

(-)

- uncomfortable proximity of the practitioner's face to the patient
- as the eye-subject distance decreases, the eyes must converge, creating eyestrain

Image size and resolving power can be increased by using lenses for magnification, with no need for the position of the object or the operator to change.

By increasing light levels, one can increase apparent resolution.

Loupes

- the most common forms of magnification
- two mono-ocular microscopes with lenses mounted side by side and angled inward (convergent optics) to focus on an object

Loupes

(1) diopter, flat-plane, single-lens loupe

(2) surgical telescope with a Galilean system configuration (2-lens system)

(3) surgical telescope with a Keplerian system configuration (prism-roof design that folds the path of light)

Diopter system

Relies on a simple magnifying lens

(+) the most inexpensive system

(-)

- the plastic lenses that it uses are not always optically correct
- the increased image size depends on being closer to the viewed object, which can compromise posture

Surgical telescopes

Multiple-lens system

Positioned at a working distance between 28-51 cm (28-38 cm)

Galilean system:

- a magnification range from 2 to 4.5
- is a small, light, and compact system

Surgical telescopes

Surgical telescopes

Keplerian system: prism loupes

- use refractive prisms
- are actually telescopes with complicated light paths, which provide magnifications up to 6

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Surgical telescopes

(+)

- superior magnification
- correct spherical and chromatic aberrations
- excellent depth of field
- are capable of increased focal length (30–45 cm), thereby reducing eyestrain and head and neck fatigue

(-)

- the practical maximum magnification is only about 4.5
- loupes with higher magnification are available, but they are heavy and unwieldy with a limited field of view.

Surgical headlamps

- can increase light levels up to 4 times that of conventional dental lights
- short working distance (35 cm)
- use fiber optic cables to transmit light (reducing heat to minimal levels)
- the fiber optic cable is attached to the doctor’s headband so that any head movement moves the light accordingly

Surgical headlight and loupes

Problem: even moderate movements of the head result in total visual dislocation and loss of the visual field, especially at higher magnifications

Dental operating microscope

- better optic
  - bipolar spatial sight
  - variable, up to 30fold magnification
- stability
- coaxial light supply, shadow-free illumination
- very high brightness up to 400 Kilolux


OPMI pico
Carl Zeiss


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1998 American Dental Association

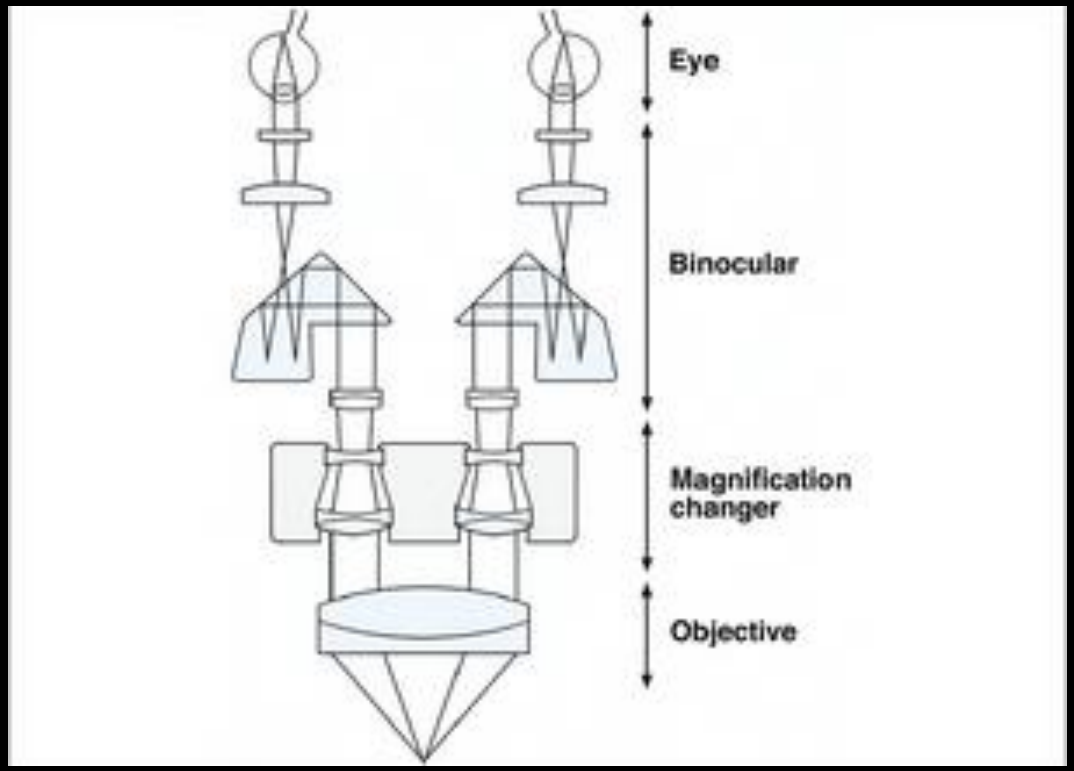
All accredited United States postgraduate programs must teach the use of the microscope in nonsurgical and surgical endodontics.

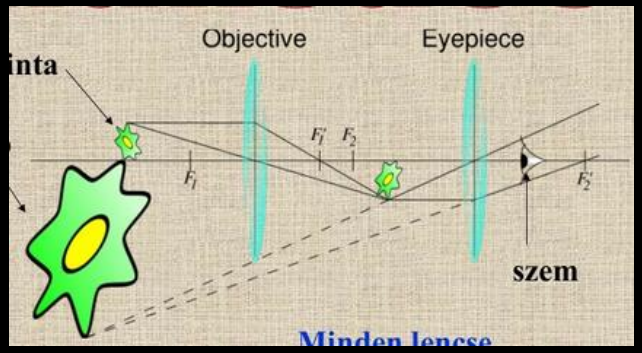
Magnification

Is determined by

- the magnification power of the eyepiece
- the focal length of the binoculars
- the magnification changer factor
- the focal length of the objective lens

Schematic diagram of the SOM





Eyepiece and objective lens are convex (converging) lenses. The eyepiece connected to binocular field glasses allows adequate focal length. The objective lens increases the magnification. The magnification changer adds to the flexibility of the microscope

Basic components

- Eyepiece has adjustable diopter settings ranging -5 to +5 (adjusting for accommodation and refractive error of the operator)

- Interpupillary distance: the distance between the two eyepieces

- Inclinable binoculars are adjustable for positions up to 220 degrees

Basic components

- Magnification changers are available as three- or five-step manual changers or power zoom changers: permits smooth transition between magnifications

Manual step changers consist of lenses that are mounted on a turret

Turning the dial (connected to the turret) rotates the turret ring inside the body of the SOM and creates five magnification factors

Basic components

- the focusing knob changes the distance between the microscope and the surgical filed

- the focal length of the objective lens determines the operating distance between the lens and the surgical filed

  Objective lens with 200 mm focal length focuses at about 20 cm: provides adequate room for surgical instruments

Calculating total magnification

$M_T = f_t / f_o \times M_e \times M_c$

M_T = total magnification

F_t = focal length of the binocular tube

F_o = focal length of the objective lens

M_e = magnification of the eyepiece

M_c = magnification factor

Optimum configurations for endodontics

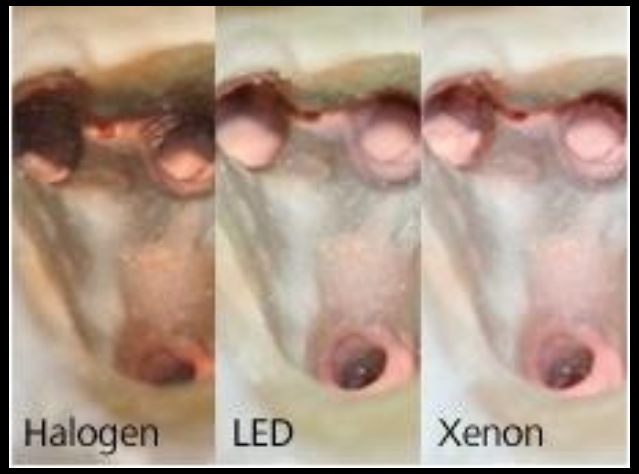
- X 12.5 eyepieces
- 200-mm objective lens
- 180-degree inclinable binoculars
- a five-step manual magnification changer / a power zoom magnification changer

Comfortable working range of about 20 cm from the patient at a magnification range of X3 to X26

Illumination

- light sources: xenon bulb/ quartz halogen bulb
- path of light: separation of the light beam: stereoscopic effect

- coaxial illumination-NO shadows



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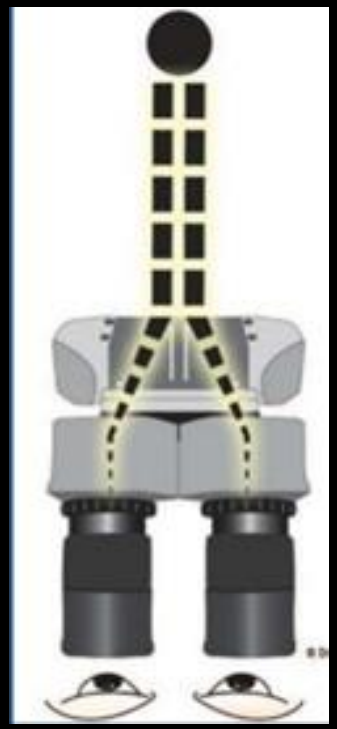
Loupes vision vs. SOM vision

- convergent vision of loupes
- stereoscope vision that provides easier eye accommodation



The beam splitter

- inserted into the pathway of light as it returns to the operator's eyes
- supply light to an accessory
  - digital camera
  - video camera
  - co-observation tube

Accessories

- observer tubes for assistant
- monitor, showing what the microscope sees
- camera, recording an image with the same magnification and field of view
- video camera

Positioning the OM

- operator positioning
- rough positioning of the patient
- positioning of the OM and focusing
- adjustment of the interpupillary distance
- fine positioning of the patient
- parfocal adjustment
- fine focus adjustment
- assistant scope adjustment

Magnification ranges

Low (X3 to X8)

- wide field of view and high focal depth
- orientation within the surgical field

Midrange (X10 to X16)

- moderate focal depth, keeps the field in focus despite small movements
- „working magnifications” in endodontics

High (X20 to X30)

- focal depth is shallow, the field moves out of focus with even slight movements
- inspection for fine detail

Prerequisites for the use of the microscope in nonsurgical endodontics

- Rubber dam placement
- Indirect view and patient head position
- Mouth mirror placement
- Some key instruments

Rubber dam & mirror placement

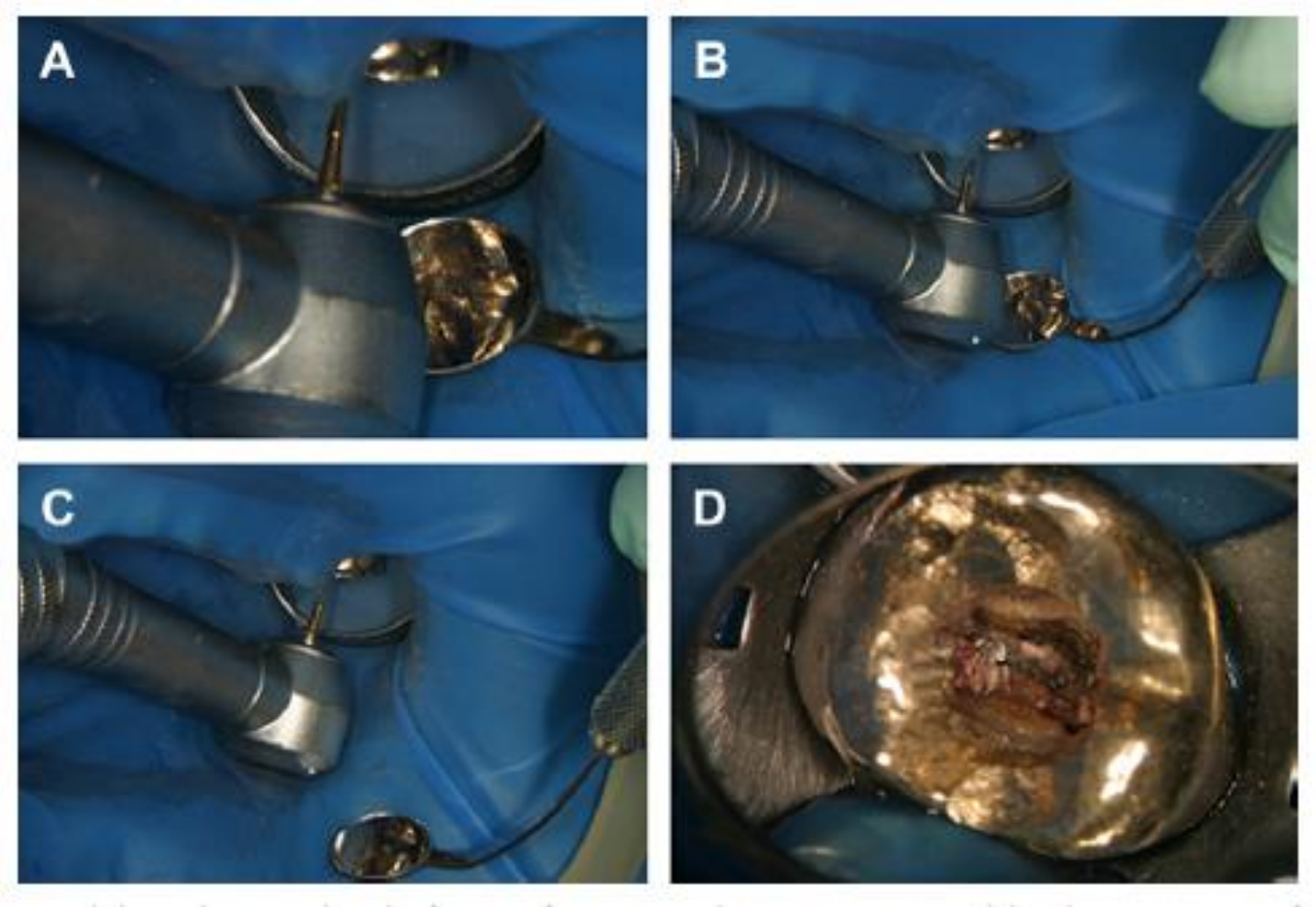
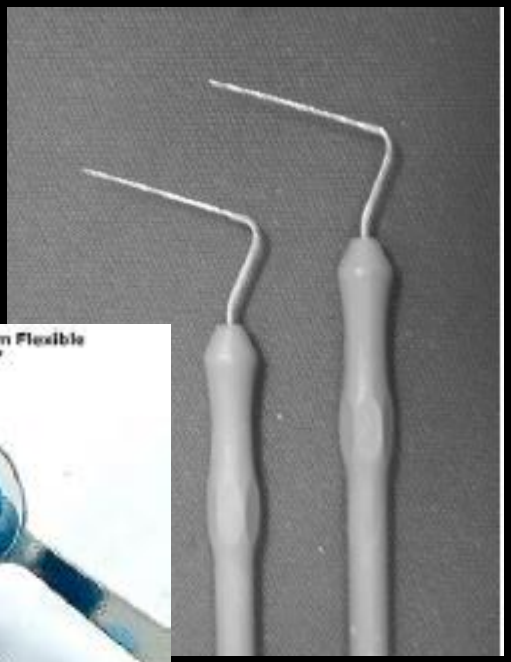
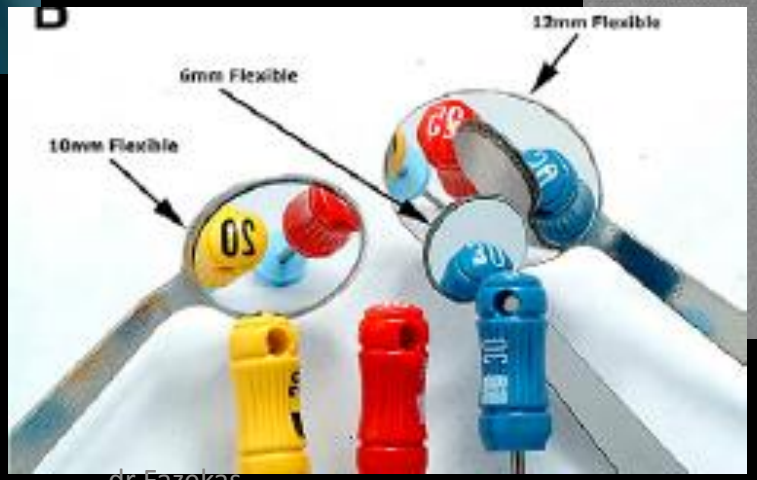


Fig. 23. (*A*) Inadequate level of magnification and mirror position. (*B*) Adequate magnification to position mirror. (*C*) Adequate mirror position. Notice the flex of the mirror staff. (*D*) Adequate magnification level with clear view of the operatory field.

Specially designed micro instruments

- micro mirror, explorer / micro opener, plugger





Must be used the microscope for all steps of nonsurgical endodontic procedures?

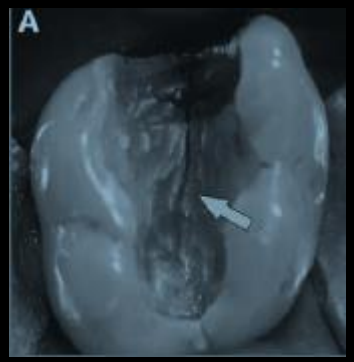
- a noble idea, but in reality, it is not needed or desired
- must consider the benefit/risk ratio

For what procedures is the microscope really essential?

- diagnosis
- locating hidden canals
- management of calcified canals
- perforation repair
- broken instrument retrieval
- final examination of the canal preparation
- surgical endodontics
- patient education

Diagnosis (!)

- detect micro fractures (methylene blue staining)



- locate canals: what was considered a rare exception in the past has become a routine finding when using the microscope
  - 50% of all molars have a 4th canal
  - 30% of all premolars have a 3rd canal
  - 25% of all anterior teeth have 2 canals

Locating hidden canals

- atypical position or form of a root canal orifice
- Isthmuses and accessory root canals

Abb. 8a Zahn 15 mit drei Wurzelkanälen. Nach initialer Darstellung der Wurzelkanäle sind ein bukkaler und ein palatinaler Wurzelkanaleingang erkennbar.

Abb. 8b Nach weitergehender apikal gerichteter Präparation lassen sich bukkal zwei Orifizien erkennen (Pfeile).

Abb. 8c Röntgenkontrollaufnahme des Zahns 15 mit drei Wurzelkanälen.

Locating hidden canals

- calcified canals
- missed canals
- aberrant canals
- dilacerated canals
- canals blocked by restorative materials

Such searches can result in perforations or gross destruction of tooth structure!

Abb. 6a Zahn 27 mit zwei palatinalen Wurzeln und fünf Wurzelkanälen (Pfeile). Der initial nierenförmig geformte Wurzelkanaleingang bukkal lässt erst nach einem Substanzabtrag von etwa 2,5 mm nach apikal die Aufteilung in drei Wurzelkanäle erkennen.

Abb. 6b Zahn 27 nach Abschluss der Wurzelkanalbehandlung mit fünf getrennt thermoplastisch gefüllten Wurzelkanälen.

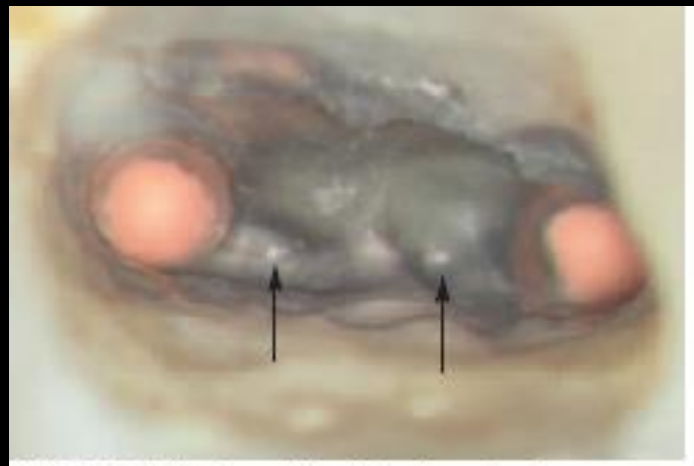
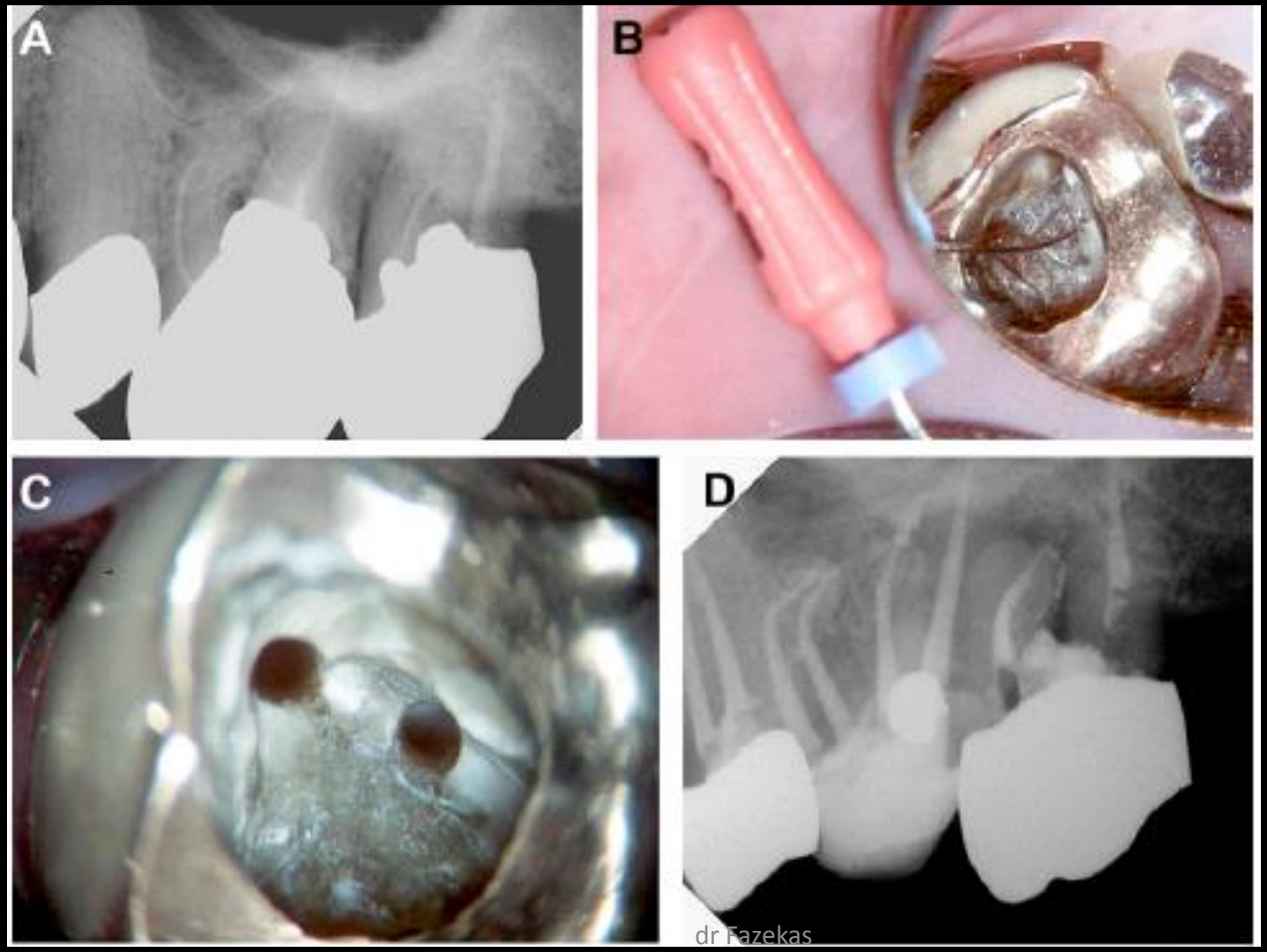


Abb. 7a Ansicht der mesialen Wurzelkanaleingänge von Zahn 46. Im Bereich des Isthmus lassen sich zwei weitere akzessorische Wurzelkanäle darstellen (Pfeile).

Abb. 7b Röntgenkontrollaufnahme des Zahns 46 nach Abschluss der Wurzelkanalbehandlung. Der lingual liegende akzessorische Wurzelkanal konfluiert mit dem mesiolingualen Wurzelkanal. Der bukkal liegende zusätzliche Wurzelkanal verläuft selbstständig nach apikal.

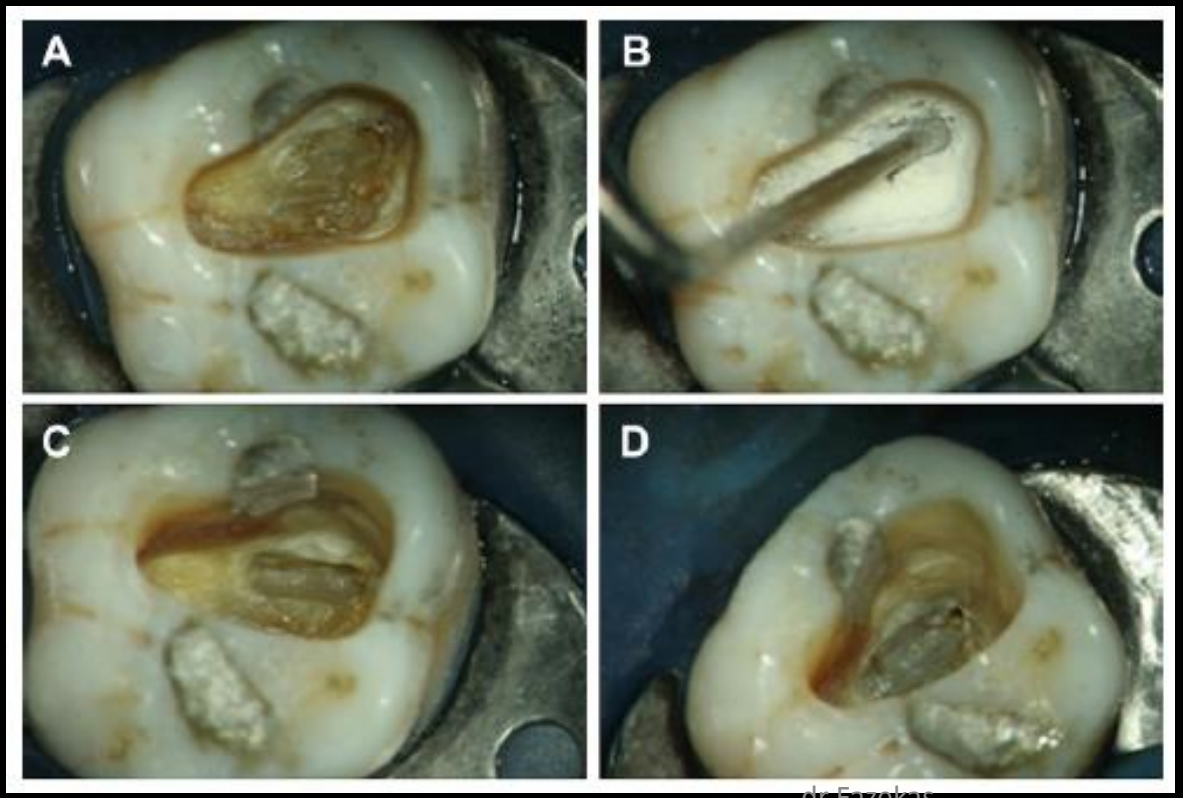
Locating hidden canals



Management of calcified canals

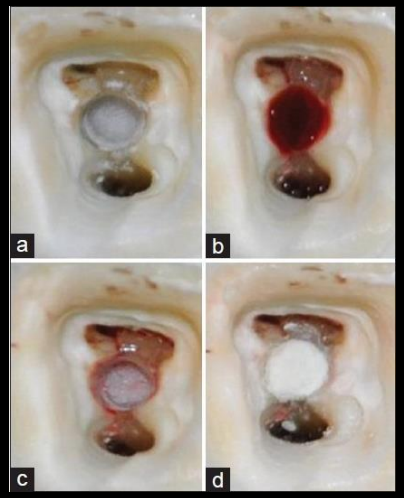
How to distinguish dentin from calcified pulp?

- changes in color, translucency, and refractive indexes
- careful probing & ultrasonic preparation



Perforation repair

- identify and evaluate the damaged site
- preparation of the perforation repair
- place the matrix precisely
- MTA cement application

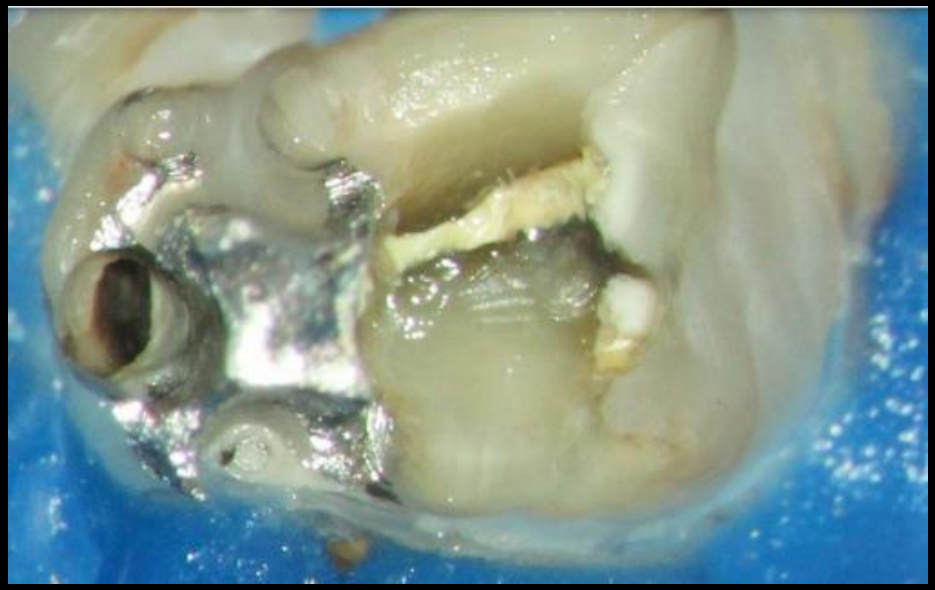


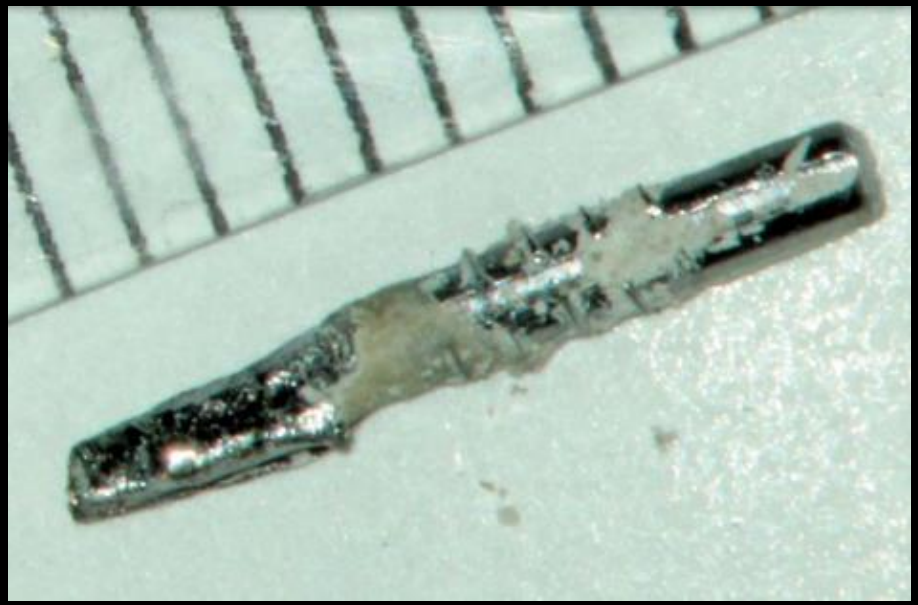
Retrieval of broken files

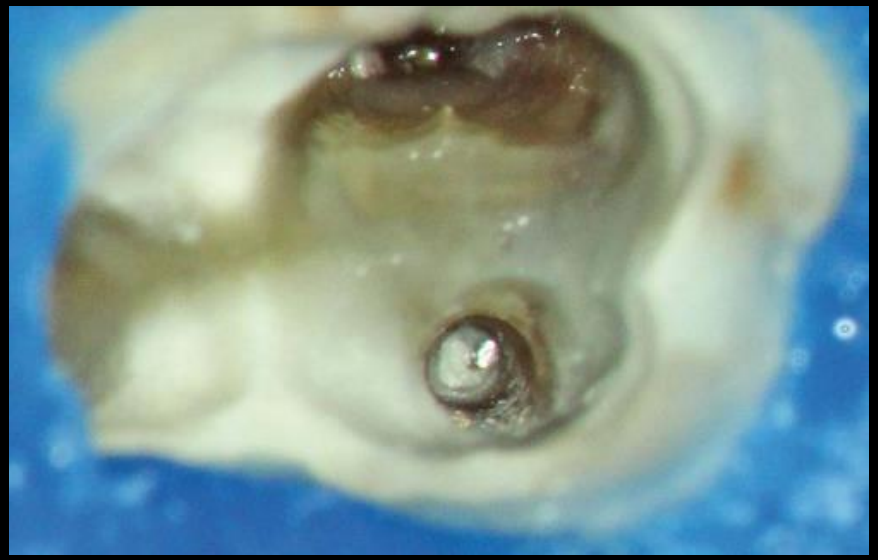
- increased incidence
- within the coronal half of the canal
- can minimizing the damage to the surrounding dentin

Retrieval of broken files

by Dr Bernhard Albers







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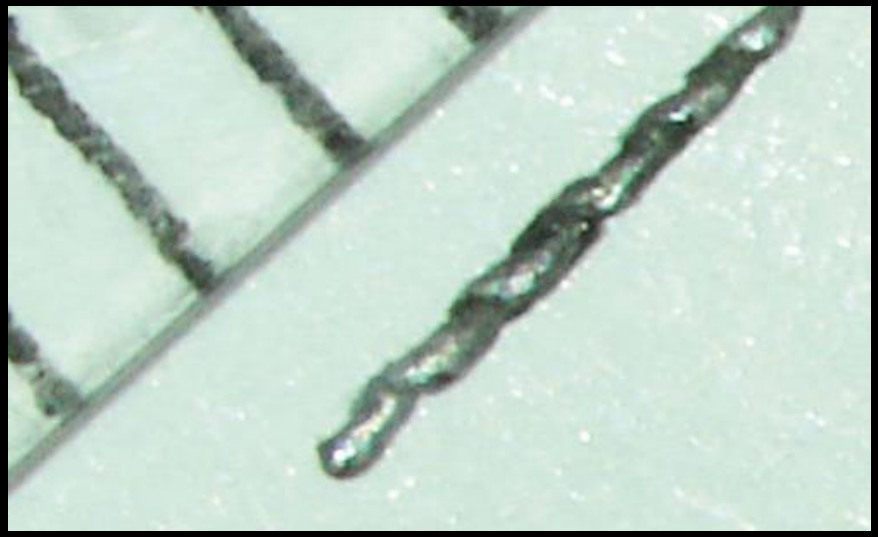
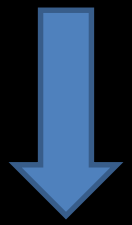


Final examination of the canal preparation

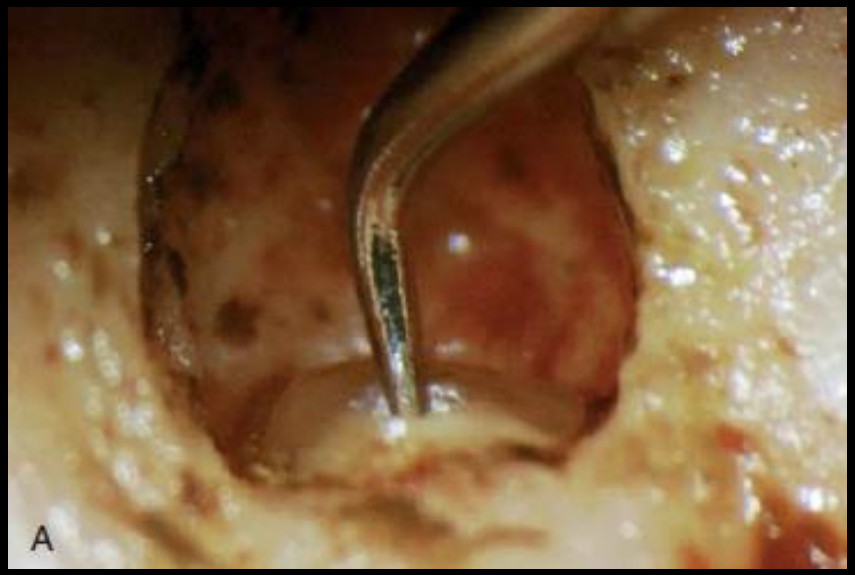
a small amount of sodium hypochlorite is deposited into the canal and observed carefully at high magnification



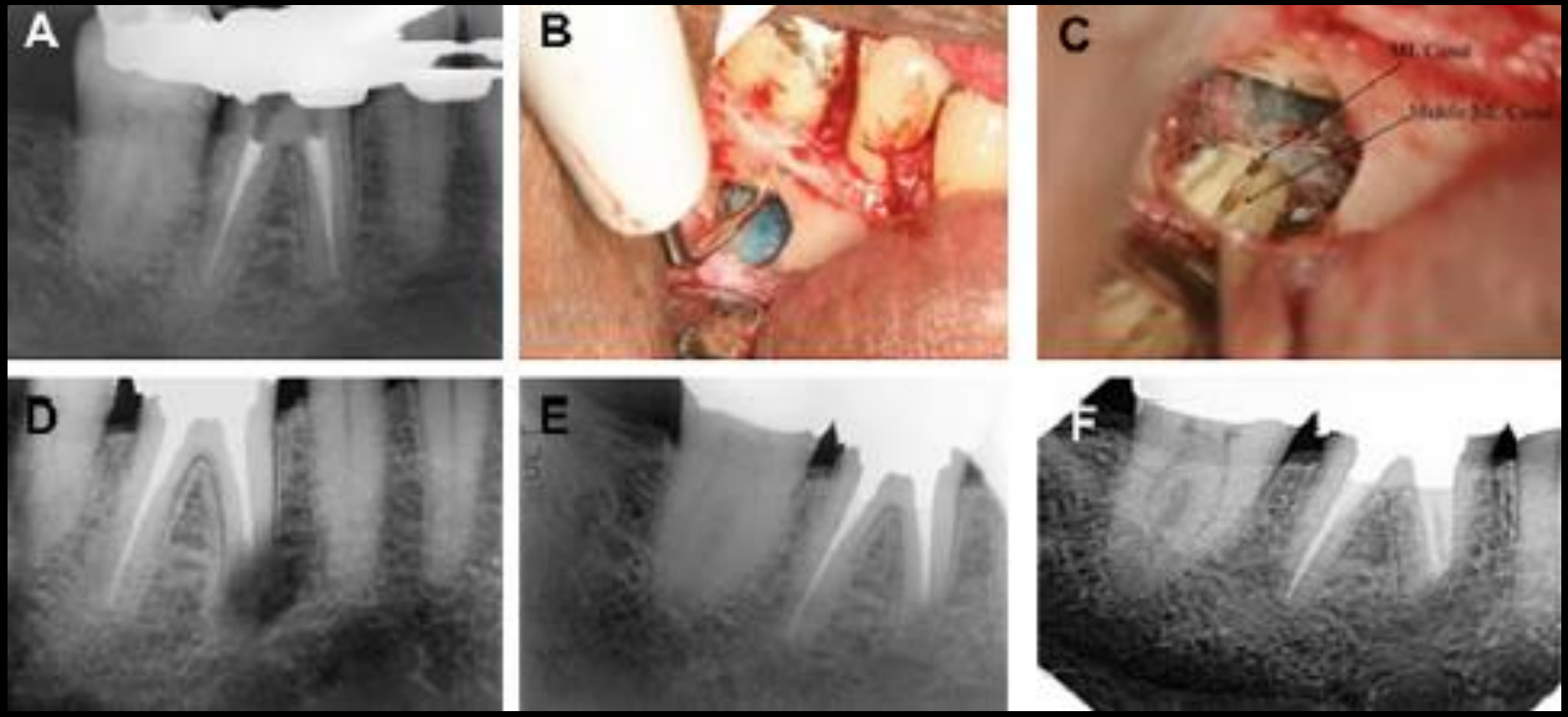
if there are bubbles coming from the prepared canal, then there is still remnant pulp tissue in the canal

Surgical endodontics

- retro mirrors, coaxial ultrasonic preparation
- moderated bevel of the root resection, retrograd root canal filling



Surgical endodontics



Advantages

- Increased visualization (0.2→ 0.006 mm)
- Improved quality and precision of treatment
- Improved and ideal treatment ergonomics
- Proper digital documentation

Disadvantages

- high initial cost of the equipment and instruments
- need for specific training
  - restricted working field: 11-55 mm
  - only the tip of the instruments is visible, delicate movements!
  - learning depth perception and orientation takes time and patience

Cost versus patient benefit

(-)

- expenditure of time and money
- initial learning curve

(+)

- less time
- greater visibility of the root canal anatomy
- complicated cases become less so under the microscope
- procedural errors can be greatly reduced
- flexibility with documentation

Take home message

- Clinical practice with operating microscopes… not a fancy, but a necessity!
- Knowledge of physics of microscopes – essential to choose microscope for dental work

Literature, pictures

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