Magnification assisted endodontics

Dr Réka Fazekas
Department of Conservative Dentistry, Semmelweis University
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.

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Different magnifications of a dollar bill as seen through an OM
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
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 headlights and loupes

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

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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
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
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

\[ M_T = \frac{f_t}{f_o} \times M_e \times M_c \]

- \(M_T\) = 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
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
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
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


