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Systematic Review

Magnification - An endodontic review

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Abstract

Technological advances and discoveries in instruments and materials have made it possible to achieve treatment objectives that once were considered unattainable in the field of dentistry. The introduction of microscopes into endodontics in the early nineties brought on a renaissance in endodontics that led to new and exciting discoveries and the blossoming of new ideas and techniques. The microscope proved to be an invaluable instrument, allowing endodontists to render treatment for problems which were previously thought to be impossible to treat. This review article provides a comprehensive review about the applications of microscopes in endodontics.

Introduction

Endodontics has progressed a long way from the old tooth worm theory prevalent in 16th theory which propagated that worms burrowing in the decayed tooth were the reason for dental pain. Treatment of diseased pulp using leech and red hot wire was the modalities followed those days.

Introduction of anesthesia has radically changed the management of pain in the medical field.[1]

Development of antiseptics rubber dam, gutta-percha, radiographs, and rotary systems were other landmarks in the progression of endodontics. State-of-the-art includes surgical operating microscope, which functions as the third eye for the endodontist. The introduction of microscopes into endodontics in the early nineties brought on a renaissance in endodontics that led to new and exciting discoveries and the blossoming of new ideas and techniques. When the surgical operating microscope was introduced in endodontics in the USA, it was a historical landmark for advances in the field of dentistry. The microscope proved to be an invaluable instrument, allowing endodontists to render treatment for problems which were previously thought to be impossible to treat.[1,2]

"Modern man is seldom amazed. However, there are still fascinating moments in dentistry. For me, looking through a surgical microscope is among these. The root canal, once ruled by darkness, is suddenly illuminated and reflects in bright light, opening its anatomical wonder of side canals, branches, notches, furrows, colored shadows, and secret passages. In many cases, the ominous Foramen physiologicum becomes visible and can almost be touched, allowing the periapex to be anticipated." - Prof. Dr. Michael A. Baumann.

Breif History

- 1977 - An otolaryngologist (ear, nose, and throat [ENT] Specialist) Dr. Robert Baumann, described the use of microscopes in dentistry.
- 1981 - The first commercially available dental operating microscope - Dentiscope, Chayes Virginia Inc. by Apotheker and Jako, The dentiscope had a single magnification of 8 and dual fiber-optic lights.
- September 25, 1982 - Harvard Dental School Boston, offered the first course in the clinical hands-on use of the dentiscope.
- March, 1993 - The first symposium on microscopic endodontic surgery was held at University of Pennsylvania School of Dental Medicine.
- 1996 - Proposal that "microscopy training be included in the new Accreditation Standards for Advanced Specialty Education Programs in Endodontics" was accepted.

New Standard of Care in Endodontics Requires

1. Magnification
2. Illumination
3. Armamentarium.

Loupes

Dental loupes are the most common and easily available form of magnification. They are basically two monocular microscopes with lenses mounted side by side and angled inward to focus on the objects. However, as the eye must converge to view the image, it can lead to a lot of strain and fatigue. Further research and development led to the Prism loupe, which are the most optically advanced magnification available. They are basically low power telescopes that use refractive prisms having better magnification, wider depths of field, and long working distance. [1,2]

Magnification range is from ×2 to ×6.

Illumination plays a key role, fiber-optic headlamps can increase light levels as much as 4 times that of traditional dental operatory. Being mounted in the center of the forehead, the light path is always in the center of the visual field.

Disadvantage

The maximum magnification is ×3.5–×4.5. Moderate movements of the head resulted in total dislocation and loss of the visual field, especially in higher magnifications.

Microscopes have the capability to go to magnifications of up to ×40 and beyond.

The main advantage of the surgical microscope compared to all loupe systems is that it is aided by coaxial illumination.

Magnifications in the range of ×2–×3 are recommended.

×2.5–×8 are used for orientation to the surgical field and allow a wide field of view.

×10–×1 are used for operating.

×20–×30 are used for observing fine detail.

The main advantages over loupes include wider fields, variable magnification, better depth of focus, and coaxial illumination.

The main benefits of the surgical microscope include, (1) Visualizing and evaluating the surgical field, (2) Patient education and marketing, (3) Reports to dentists and insurance companies, (4) Dental legal purposes, (5) Teaching programs, (7) Marketing the dental practice.[3]

Magnification

Determined by:
1. Power of the eyepiece
2. Focal length of the binoculars
3. Magnification changer factor
4. Focal length of the objective lens.

Anatomy of Surgical Operating Microscope

Eyepiece

- Available in powers of ×6.3, ×10, ×12.5, ×16, and ×20.
- Adjustable diopter settings.
- Ranging from - 5 to + 5.

Binoculars

Function

To project an intermediate image into the focal plane of the eyepiece:
- Positioning of the eyepieces.
- Interpupillary distance is set by adjusting the distance between the two binocular tubes, once set, need not be changed unless the microscope is used by another surgeon with different optical requirements.
- They come in different focal lengths which can either be straight or inclined tubes.
- Longer the focal length, the greater the magnification and the narrower the field of view.

Straight tube binoculars are orientated parallel to the head of the microscope allowing direct vision to the surgical field. This system is used by ENT surgeons. The dental chair is placed below the operator for maxillary surgery and slightly above the operator for mandibular surgery. This allows the clinician to look down the axial plane of the root in maxillary teeth and up the axial plane of the root in mandibular teeth. Straight tube binoculars gain even more versatility when a 135° inclined coupler or variable inclined coupler is placed between the mounting arm and the microscope. This coupler provides an additional axis of rotation and aligns the microscope so that straight tube binoculars provide direct vision whether the patient is sitting up or lying down.[4,5]

Inclined binoculars are orientated so that the tubes are offset at 45° to the head of the microscope used for maxillary surgery, for mandibular surgery, but the operator has to use indirect vision through a mirror.

They can be adjustable between the straight tube and slightly beyond up to 180°. Inclinable tube binoculars allow the surgeon to look directly at the maxillary arches and mandibular arches and have the advantage of the other binoculars, thus providing more comfort during long endodontic surgeries.

However, they are difficult to engineer and expensive.

Objective lens

Focal length is determined by the objective lens and the operating distance between the lens and the surgical field. They range from 100 to 400 mm.
- 175-mm lens focuses at 7 inches
- 200-mm lens focuses at 8 inches, and
- 400-mm lens focuses at 16 inches.

A 200-mm objective lens is the preferred one as there is adequate room to place surgical instruments and still be close to the patient.[6]

Total Magnification

$M_T = f_t/f_o \times M_e \times M_c$
M_T = Total magnification
f_t = Focal length of binocular lens
f_o = Focal length of objective lens
M_e= Magnification of the eyepiece
M_c = Magnification factor

Parfocalization

- Setting the operator specific focus throughout the entire range of magnification.
- It should be parfocalled once a month to keep it properly focussed even for subtly changing eyesight.
- It prevents unnecessary eye fatigue and pain.

In addition, when the microscope is parfocused, accessories such as cameras and auxiliary binoculars are also in focus.

To parfocal a microscope, a flat object, such as a dull copper penny is placed under the microscope and focused at the highest magnification.

The left/right eye diopter settings are unique to each person and should be written especially if the microscope is shared.

Optimum Configuration for Endodontic Microsurgery

- ×12.5 eyepieces with a reticule
- 200–250 mm objective lens
- 180° inclinable binoculars
- 5 step manual magnification changer or power zoom magnification changer
- It should be about 8 inches from the patient
- Range is between ×3 and ×26.

Illumination

It is important to understand the path light takes when it travels through the microscope. A 100-watt xenon halogen bulb, controlled by a rheostat and cooled by a fan. After the light reaches the surgical field, it is reflected back through the objective lens, through the magnification changer lenses, and the binoculars and then exits to the eyes as two separate beams of light. The stereoscopic effect is produced by the separation of light beams and allows the clinician to see the depth of field.[7,8]

- 100 W Xenon halogen bulb in a fan cooled system
- Fiber-optic light (Quartz halogen bulb is focused onto the end of the fibre-optic cable).
- Xenon bulb - Brighter (comparable to daylight)
- Color temp of 56000 K
- Produces a true color picture
- Quartz Halogen light - Color temp of 32000 K
- Produces a yellow picture.

Illumination of the surgical microscope is coaxial with the line of sight. This means that light is focused between the eyepieces in such a fashion that the clinician can look into the surgical site without seeing any shadows as it uses Galilean optics.[9]

Beam Splitter

It is in the optical pathway of the microscope as it returns to the operator's eyes, thereby supplying light to an accessory such as a camera or an auxiliary observation tube. As the beam splitter divides each path of light separately, up to two accessories can be added. In addition to 50:50 beam splitters, other configurations are also available.[10]

Documentation

Documentation is an important benefit of using the surgical microscope:

- Video adapter
- Video camera
- Video printer

Purpose of documentation:

1. To communicate with the referring dentist
2. To educate patients and students
3. To maintain the required legal documentation of each case.[11,12]

Accessories

Many accessories are made for the operating microscope:

- Bicycle style handles and piston grips are used and help inconvenience and movement during surgery.
- Articulating and auxiliary monocular binoculars can also be added.
- Liquid crystal display screen.

The features of an endodontic microscope should include:

1. Excellent optics
2. Mechanical stability
3. Maneuverability
4. Modularity.

The most important aspect, the quality of the optics, is very difficult to assess. Fortunately, most microscopes on the market have excellent optics. At present, microscopic optics are made in Brazil Seiler), Germany (Kaps, Leica, Moller, and Zeiss), Japan (Nikon, Olympus), and the United States (Global).

Mechanical stability is the second most important criterion in selecting a microscope. Since the microscope must be repositioned many times during a procedure to accommodate changes in the patient's head position, it is important that the microscope stop moving immediately after being repositioned. The stability of microscopes varies greatly. The microscope should not drift, and the arm should not "bounce" after being moved. To test for mechanical stability, the dentist can gently tap the end of the arm of the microscope when it is fully extended. In a good microscope, superior suspension and balance mechanisms prevent the arm from moving or bouncing in response to position adjustments.

Maneuverability of the microscope is essential because a patient's head moves frequently, either to adjust position or due to involuntary muscle activity. The microscope head has to be light for almost effortless maneuverability. For this reason, it is not advisable to add an assistant scope or any other large or heavy accessories.

Since a microscope is a lifetime investment, modularity or adaptability is an important factor. The requirements for the microscope will change with the user's needs, and other sophisticated features can be added as experience dictates. For instance, manual magnification can be changed to an automatic zoom function. Some microscopes are fully modular, whereas others are limited in this respect. It, therefore, is important to check with the manufacturers about the modularity of the microscope before it is purchased.

Magnification

"How powerful is a particular microscope?"

The maximum object magnification that can be used in a given clinical situation relative to the depth of field and field of view, i.e., "USABLE POWER" should be kept in mind. As magnification increases, the depth of field is decreased, and the field of view is narrowed.

Illumination

There is a limit to the amount of illumination a surgical microscope can provide. As magnification increases, the effective aperture of the microscope is decreased, thus the amount of light that can reach the surgeon's eyes is reduces, and the surgical field appears darker.

Depth perception

The clinician must feel comfortable receiving instruments and placing it between the microscope and surgical field. This takes time and patience. Coordination and muscle memory has to be developed over time. As a general rule, the clinician should reorient himself or herself to the microscope before beginning each surgery.

Access

The surgical microscope does not improve access during surgery. If access is limited for conventional surgery, it is even more limited when the microscope is placed between the surgeon and the surgical field. However, it creates a much better view of the surgical field as a result of which cases can now be treated with a higher degree of confidence.

Flap design and suturing

Soft tissue reflection, flap designing, and suturing are not high magnification procedures. The operating microscope is recommended predominately for osteotomy, curettage, apicectomy, apical preparation, retrofilling, and documentation.[13]

Dentists

- Greater reliability better quality, diagnosis, and therapy
- Greater comfort - upright posture
- Greater differentiation - better image.

Patients

- Greater likelihood of successful treatment
- Faster healing - less traumatization
- Tooth conservation instead of tooth replacement
- Cost-effective
- No scars - cosmetic benefits.

Disadvantages

- Costly equipment
- Patient cooperation is a must
- Needs a lot of surgeon's skill and experience.

The microscope in practice

The simple premise for using the microscope is that:

Light + Magnification = Excellence.

Endodontic microscopy and its implication can be categorized into six areas:

1. Diagnosis
2. Nonsurgical endodontics
3. Surgical endodontics
4. Documentation and patient education
5. Marketing
6. Revitalization of your career.

A number of fundamental requirements must be met before mastery of the use of the microscope can be attained.

- Vision (indirect vision)
- Adequate illumination, and
- Patient compliance.

Diagnosis

1. Visualizing the root canal system in fine detail
2. Detecting microfractures (fracture line in root and crown)
3. Distinguish the floor and dentin
4. Locate small canal orifice
5. Examining dental caries
6. Examining crown margins
7. Observe sub - gingival defects
8. Observe complex anatomical situation.

Other uses

- Removal of pulp stones in the canal orifice facilitated by

accurate placement of ultrasonic tip around it and thus preventing unnecessary removal of radicular dentin.
- For diagnosis and management of perforation.
- Repair by scaling of the defect with or without a matrix.
- Locating calcified canals.
- Retrieval of broken down or separated instrument:
- Helps to see the instrument within the canal and pinpoint precisely where to trough with the ultrasonic instrument.
- Management of procedural errors.
- Also helps in post removal.

Thus, increased likelihood of a successful outcome, because it helps in locating extra canals and anatomy of the tooth is more readily visualized.[14]

Surgical Endodontics

1. Osteotomy (précised and small – 5 mm)
2. Curettage
3. Apicectomy
4. Inspection of the resected root surface
5. Detect apical perforation
6. Apical preparation
7. Retro filling
8. Examination of surgical site
9. Identify and manage isthmus
10. Post-operative healing - use of fine sutures with precision quick uneventful healing.

Conclusion

Without a doubt, the greatest revolution with microscopes was in root-tip resection. Today, using the trifecta of magnification - illumination - instrumentation, an excellent, retrograde, microsurgical root-tip resection, can be carried out under a surgical microscope with optimal illumination and using ultrasound-supported retrograde treatment and a special micro-instrument. New horizons were, and will still be opened for surgical microscopes in endodontics. Without a doubt, the quality of the results will increase. The goal of microscopes is to achieve the highest possible precision while providing maximum protection to healthy tissue. The advantage lies in minimal trauma to the treated tissue and increased security in achieving the desired result. For patients, this means less pain, shorter healing times, greater probability of reaching the desired result (e.g., as regards aesthetics) and better long-term results.

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