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Magnification - The third eye in endodontics: A review.

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Abstract : *In recent times dentistry has become more complex thus, requiring precise motor expertise and visual acuity. During past years, dentistry has not only progressed clinically but the histological aspects has also played an essential part in the advancement of new materials as well as helped in better evaluation of treatment procedures. Hence, this review article details about the promising options of magnification such as dental loupes, optical microscopes, surgical operating microscopes, endoscopes, and orascopes.*

Keywords: *magnification, microscopes, loupes, rod-lens endoscope,(10 Italic)*

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I. Introduction

Endodontics practice requires precision and great attention which depends on the training, skills and experience of the clinician. Most endodontic procedures are carried out in blindly with tactile sensation and fractions of millimetres may decide the result of the treatment. Over the past decades, endodontics has gained not only basic and clinical scientific knowledge, but also has taken technological significant rises. Due to the complex nature of endodontic treatment, practitioners have always pursued to improve their vision of the operational field. Hence, magnification aids were used which helps in apparent increase in size of the field especially by the use of lenses. The use of optical magnification instruments such as loupes, microscope, endoscope & orascopes enables the endodontist to magnify a specified treatment field beyond that perceived by the naked eye. The maximum magnification of human eye is 0.068 cm also called as 1x magnification, which can be increased to 2.5x to 40x with the help of magnifying instruments [(1)]. Magnification affects the vision by increasing the size of an image on the retina.

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II. Objectives of magnification in dentistry

1. Enhance visualization
2. Extraocular muscles to remain relaxed.
3. The operator to maintain normal posture

In clinical procedure:

1. Improve precision
2. increase the quality of work
3. increase the success rate

Magnification used in dentistry:

- Loupes
1. Single lens loupes
2. Multi-lens loupes
- Galilean optic loupes
- Prism optic loupes
- Dental operating microscope
- Rod-lens endoscope
- Orascope

III. History

The use of magnification date back to 2,800 years, when simple glass meniscus lenses were described in Egypt. In 1694, Anton van Leeuwenhoek, constructed first compound lens microscope. In 1876, Magnification was introduced in dentistry. In 1978, Apotheker & Jako, first introduced the microscope to dentistry. In 1981, Dentiscope was introduced. In 1986, Microsurgery has been practiced in endodontics. In 1994, the first microscopes were routinely used for restorative dentistry. In 1999, Gary Carr introduced dental operating microscope with Galilean optics. In 2002, the Academy of Microscope Enhanced Dentistry is formed.(2,3)

IV. Loupes

Dental loupes are the most commonly used magnification system in dentistry. These are fundamentally two monocular microscopes, with side by-side lenses, angled to centre an object. The enlarged image that is formed has stereoscopic properties that are created by the use of convergent lens systems. All loupes uses convergent to form a magnified image. The most used & suggested working distance is between 11 & 15 inches (28 to 38 cm).(1)

Classification of loupes (4)

Based on the number of lens as:

1. Single lens
2. Multiple lens:

- Galilean optic loupes
- Prism loupes.

Based on magnification system:

1. Flat plane , single lens loupes
2. Surgical telescope with Galilean optical system
3. Surgical telescope with keplarian optical system

4.1. Single lens loupes:

Single-lens magnifiers produce the described dioptre. It provides magnification that simply adjust the working distance to a set length. An increase dioptres decrease working distances. They provide fixed focal length & working distance. It is Light weight & low cost. But, provide poor imaging resolution compared to multi-lens loupes. The set working distance creates difficulty in maintaining focus and, therefore, may cause neck and back strain from poor posture.(5)

4.2. Multi-lens loupes:

Compound loupes use multiple lenses with intervening air spaces which allow an adjustment of magnification, working distance, and depth of the field without excessive increase in size or weight. There are two types of multi-lens loupes Galilean loupes & Prism loupes.(5)

4.3. Loupes with galiliean optical system:

Galileo galilee introduced this optical system in 1609.This type of glass with multi-lens system is known as Galilean optical system. This type's optical system uses 2 lens that is Convergent objective lens (plano convex) & Divergent eyepiece lens (Plano concave). The Ideal magnification of this loupes is 2.5x. But, the magnification ranges are 2x to 4.5x. This type of loupes provides higher level of magnification, improved depth of field & working distance, & higher optical resolution compared with single lens optics, it is light in weight and also inexpensive. As SILBER stated that the use of loupes beyond x2.5 limits the depth of field & working distance, hence, this type of loupes cannot offer magnification much more than x2.5 without incurring weight, size, & image resolution. When used beyond x2.5, it will move the treatment field in & out of focus which will distract the operator & give a blurry peripheral border of the visual field.(4,5)

4.4. Prism optics (or wide-field loupes):

This optical system is based on the Keplarian astronomic telescope, which uses 5 lens & 2 prisms. The Keplerian Telescope, which was invented by Johannes Kepler in 1611, is an improvement on Galileo's design. These type of loupes uses convex lens as the eyepiece instead of Galileo's concave one. These loupes have prism fixed at the top, i.e., they are called as rooftop or Schmidt prisms. The ranges of magnification of such loupes are around 1.5x to 6x. They are the most optically advanced type of loupe magnification, which offers improved ergonomic posture as well as major advancements in optical performance. It provides a superior optical clarity & flatter view from edge to edge but, it is slightly heavy & expensive.(5)

V. Dental operating microscope

Baumann was the first to report the use & benefits of an operating microscope for conventional endodontics. On January 1, 1998, the American Dental Association Accreditation Standards for Advanced Speciality education programs in endodontics were revised; formal microscope training must be included in surgical and non-surgical endodontic treatment. Microscope uses the Galilean lens system.[5]

Classification:
Based on magnification [6]:
1. Lower magnification (2.5x to 8x)
2. Midrange magnification (8x to 14x)
3. Higher range magnification (14x to 30x)

Classification based on instalment as:
1. Floor type
2. Ceiling mounted
3. Wall mounted

Optical principles of a dental operating microscope:

The surgical microscope is a complicated system of lenses that allows stereoscopic vision at a magnification of roughly 4-40X with an outstanding illumination of the working area. The light beams fall parallel onto the retina of the observer so that no eye convergence is necessary and the demand on the lateral rectus muscles is decreased.[1]

It is discussed under four headings:
1. Magnification.
2. Illumination.
3. Documentation.
4. Accessories.

5.1. Magnification:

Magnification is determined by Power of eye piece:
Eyepiece has diopter setting ranging from -5 to +5.These are used to adjust for accommodation which is ability to focus the lens of eyes.

Focal length of binocular:

Binocular holds the eyepiece& the pupillary distance is set by adjusting the distance between binocular tube. Longer the focal length, greater is the magnification narrower the field of view.

Focal length of objective lens:

Focal length of objective lens determines the operating distance between the lens and the surgical field. For surgical operative microscope, a variety of objective lenses is available with focal length ranging from 100 – 400mm

Magnification change factor:

These are located within the head of microscope and manual step changer consist of lens which are mounted on a turret which is jointed to a dial. The dial positions 1 lens in front of other within the changer to produce a fixed magnification value.

Total magnification of a microscope is represented by the following formulae [7]
TM = (FLT/FLOL) x EP x MV
1. TM: Total magnification
2. FLT: Focal length of tube
3. FLOL: Focal length of objective lens
4. EP: Eye piece power
5. MV: Magnification value

5.2. Illumination:

Illumination is one of the most important feature of microscope. The light intensity are controlled by a rheostat and cooled by a fan. Rays of light passes through the condensing lens then to the series of prisms then the objective lens then to the surgical site. Surgical microscope uses coaxial fibre-optic illumination producing an adjustable, bright, uniformly illuminated, shadow free, circular spot of light that is parallel to the optical viewing axis. Commonly used light source is 100 watt xenon halogen bulb.[8]

5.3. Documentation:

The ability to produce quality video slide is directly related to magnification and illumination. Photo and cine adapters deliver the necessary focal length so that the cameras record an image with the same magnification and field of view as seen by the operator. As the 35 mm camera gets only half the available light and due to the relative insensitivity of colour photographic film, it is usually necessary to supplement the microscope's lighting system with a strobe over the objective lens. The strobe is a device used to produce regular flashes of light. Documentation can be done by videotape which is an extremely sensitive format and does not need supplemental light. The video printers can be linked to a videocassette recorder or the video camera on the microscope. A microcomputer inside the video printer automatically analyses the image, and prints are created in 70 seconds by a high density sublimation dye. Video prints can be used for patient education, medico-legal documentation, or reports to referring dentists and insurance companies.[8]

5.4. Accessories:

Different accessories used are :[8]

1. Bicycle handle attached at bottom of head to facilitate movement during surgery.
2. Eyepiece with reticle field for alignment during videotaping & photography.
3. Observation ports can be added to the microscope by a beam splitter and can be helpful in teaching situations.
4. Auxiliary monocular or articulating binoculars can also be added and used by a dental assistant.
5. LCD screen so as to provide view to patient as well as the assistant.

Parts of operating microscope:

- Supporting structure.
- Body of the microscope

1. Eyepiece
2. Binoculars
3. Magnification changer
4. Objective lens.

- Light source.

Fundamental requirements before using the microscope:

Vision: Front surface quality mirror which is silvered on the surface of glass should be used for having best quality undistorted reflected images.

Lightening: Inbuilt light source is present in the microscope, if necessary an auxiliary light can be used perpendicular to the long axis of the tooth at the level of pulp chamber.

Patient compliance: Even the slightest movement of patient's head can affect the field of vision. For optimal view through microscope, u-shaped inflatable pillow should be provided.

Cooperation from dental assistance: dental assistance can also be helpful in increasing the efficiency of clinician. The dental assistance should be adequately trained for use microscope.

Rubber dam placement: This is necessary as direct viewing with microscope is difficult.
For absorbing reflected light & to accentuate tooth structure, blue or green dam sheet is recommended

Mouth mirror placement: should be placed slightly away from the tooth, if placed close to the tooth it will make difficulties while using endodontics instruments.

Indirect view & patient's head position: Mirror should be placed at 45 degree to the microscope. For indirect viewing patient's head should be positioned such that it form 90 degree angle. Between the binocular & the maxillary arch.

Instruments: Use of micro instrument such as micro-opener, micro mirrors , micro explorers, micro restorative and endodontic instruments and hand spreaders instead of finger spreaders, rotary files instead of hand files. In order to avoid an unfavourable metallic glare under the light of the microscope, the instruments often have a coloured coating surface. The instruments should be approximately 18 cm long. The weight of each instrument should not exceed 15-20 g (0.15-0.20 N) in order to avoid hand and arm muscle fatigue.[9,10]

Sterilization:

Parts of microscope such as the rubber caps, sleeves & handgrip can be sterilised in autoclave at 134º C for 10 minutes. Other non-sterilisable parts can be cleaned using a moist cloth. Any residue can be wiped off using a mixture of 50% ethyl alcohol + 50% distilled water + a dash of household dish-washing liquid.

Advantages of surgical operating microscope:

1. Increased visualisation of the operating field.
2. Enhanced visualisation in locating the canals.
3. Diagnosis of micro fractures.
4. Perforation repair.
5. Case documentation is possible.
6. Improved Quality and precision of treatment.
7. Improved & Ideal treatment Ergonomics.
8. Low strain to the eye.

Disadvantages of surgical operating microscope :[11]

1. Saunders & Saunders have stated that the most common reasons for endodontist not using SOM during treatment is due to positional difficulties, inconvenience, & increased treatment time.
2. As a DOM has a restricted working field, 11mm -55mm .An operator using a DOM can see only the tip of the instruments, and they are used in delicate movements of small amplitude.
3. Relatively high initial cost of the equipment and instruments.
4. Specialized education and training required- e.g. High degree of surgical techniques and understanding of optics essential.
5. Prolonged adjustment period.
6. Prolonged pre surgical preparations
7. Expensive to patients
8. Limited surgical access

VI. Rod – lens endoscope

The used of rod – lens endoscope in endodontics was first reported in 1979. In 1996 the rod – lens endoscope was recommended as magnification instrument. The rod – lens endoscope consist of: Rods of glass working in junction with a camera, light source and monitor. The option of a digital recorder may be added to the system for documentation. It provides greater magnification then loupes or microscope. It has an optical resolution comparable with that of microscope or loupes.[5]

The recommended rod – lens endoscope size for endodontics surgical application are:
1) 2.7mm lens diameter, 70 degree angulation, 3cm length rod – lens.
2) 4mm lens diameter, 30 degree angulation, 4cm length rod – lens.

Requirement for using rod-lens endoscope:

1. A pair of x2 to x2.5 loupes should be used for visualization prior to the used of endoscope.
2. Haemostasis of the surgical field must be obtained
3. Prior to usage, a protective metal sheath is placed over the endoscope to add rigidity & allow the endoscope to keep in a stable position.
4. The clinician should hold the endoscope while the assistant retract gingival tissue and suction.

Advantages:

Greater magnification than loupes & microscope but, difficult to maintain a fixed field of vision compared with a microscope, hence the use of endoscope is therefore recommended for visualization of surgical endodontic treatment.
Disadvantages:
Bulky

VII. Orascope

This is a fibre optic endoscope & which works in injunction with camera, light source & monitor. These fibre optics are made up of plastic, and hence it is light weight, small &flexible. The fibre optic endoscope is design for intracanal visualization. The orascope has a 0.8mm tip diameter and 0 degree lens and working portion is 15mm in length. The orascope is made up of 10000 parallel visual fibre. Each visual fibre is between 3.7 and 5 µm in diameter. A ring of much larger light transmitting fibres surrounds the visual fibre for illumination of a treatment field.(5)

Requirement before placement of 0.8mm fibre optic scope:

1. X 2 to X 2.5 or SOM to be used for conventional endodontic visualization during access of the canals.
2. The canal must be prepared to a minimum size of 90 file in the coronal 15mm of the canal, this is to prevent wedging of the orascope which may damage some of the optics fibre will also allow the full 15mm of the scope to penetrate within the canal.
3. The canal must be dried before the placement of the orascope.

The focus and depth of field of an orascope is 0mm to infinity. This allows the orascope to provide the imaging of the apical 3rd of the root without actually having to be place in this region of the canal. Due to the temperature and humidity difference between the dental operatory and canal can cause moisture to condense on the fibre optic lens causing fogging. This can be eliminated with the use of lens antifog solution.

VIII. Conclusion

The use of magnifying aids has provided endodontics with a significant improvement in vision of the operative field, enhancing visualization, simplifies work, offering better quality job , dental procedure can be performed more accurately & more reliably using variable & adjustable magnification and a higher success rate. Hence, every clinician should use any type of magnification tools available for better treatment outcome.

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