

Magnification in Endodontics: A Review

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Abstract

Over the past decade in the field of endodontics technological advances occurred. Magnification helps the user not only see more, but to see well and can improve the performance of dental procedures. These advances have enabled clinicians to complete procedures that were once considered impossible or that could be performed only by talented or lucky clinicians. Hence, this review article details about the promising options of magnification such as dental loupes, optical microscopes.

Keywords: Magnification, Dental Loupes, Operating Microscope, Ergonomics.

Introduction

"You can only treat what you can see": Syngcuk Kim

The successful endodontic therapy is thorough mechanical and chemical cleansing of the entire root canal system, followed by its complete obturation with an inert filling material. Creating an ideal access opening is one of the most important steps to ensure a successful endodontic procedure. At the same time, the inability to identify and adequately treat all the canals of the endodontic system is a major cause for treatment failure and persistence of disease.^[1] Usage of magnifying devices has revolutionized the dental practice. This is indeed an evolution from the conventional methods of macrodentistry to a high precision microdentistry. Almost all spheres of precision dentistry have adopted these microscopic devices.^[2]

Objective 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^[3]

Historical background

- Anton van Leeuwenhook, 1694 –constructed first compound lens microscope.
- 1876- magnification was introduced to dentistry.
- Nylen, 1922 – first performed eye surgery under a microscope.
- Barraquer, 1950s- began using microscope for corneal surgery.
- 1960s – microsurgery was standard in many specialities such as neurology & ophthalmology.
- 1970s & 1980s - First articles about using a microscope in Odontology Dentistry were published .
- Apotheke & Jako, 1978 – first introduced the microscope to dentistry.
- 1986 – microsurgery has been practiced in endodontics.
- 1990s - systematic use of surgical microscopes started and was applied by the different odontological dentistry specialities, such as Periodontal Surgery.
- Carr, 1992- published an article outlining the use of a surgical microscope during endodontic procedures.
- Shanellec & Tibbetts, 1993 – Presented a continuing education course on periodontal microsurgery at the annual meeting of the American Academy of Periodontology.
- 1994—The first microscopes were routinely used for restorative dentistry.

- 1999—The American Association of Endodontists required all endodontic graduate students to be microscope proficient.
- 2002—The Academy of Microscope Enhanced Dentistry is formed.
- 2005—Several dental schools integrate microscopes into undergraduate programs^[4]

Vision and optics

There are a number of optical principles specifically related to magnifying loupes that are important to the wearer:

Field of view

As the magnification increases, the field that can be viewed decreases. It is possible to obtain loupes that magnify by as much as x6. However, in practical terms, a magnification of x2–x2.5 would enable the dental operator to see multiple quadrant areas in focus. This is the magnification normally used in general dental practice and is recommended for new users. At magnifications of x3.5 the field becomes restricted to a single quadrant, while at a magnification beyond x3.5 the view becomes increasingly restricted until only a single tooth is seen. This makes high magnification unsuitable for routine operative dentistry, but is helpful when undertaking specific procedures such as endodontics.^[5]

Depth of field

The depth of field refers to the ability of the lens system to focus on both near and far objects without having to change position. For normal vision, this ranges from working distance to infinity. The use of magnification causes a restriction in the depth of field and, as the magnification increases, the depth of field decreases to the point that only a small object is sharply in focus and everything around is out of focus. At high magnification, slight movements of the operator or patient will result in

loss of focus of the area under examination, making working more difficult.^[5]

Declination (viewing) angle

This is the angle at which a lens is set to a horizontal reference line drawn from the superior auricular crevice to the bridge of the nose and will determine the sight line. When operating, the greater the angle with respect to this line, the greater the neck tilt necessary to view the object. It is ergonomically important to make sure that this angle is correct for the individual, in order to minimize strain on the neck, back and shoulders.^[5]

Interpupillary distance

It is the key adjustment for the use of any magnification system. The ideal way to understand your IPD is to focus both the binocular eyepieces to initially see two images or circles and adjust it to the point, wherein they merge and become one circle. That point would be identified as the IPD and used as a permanent reference for the use of magnifications. The IPD varies with each individual and forms an important aspect in the learning curve of use magnifications.^[6]

Dental Loupes

Loupes are not a new invention. Magnifying loupes were innovated to address the problem of proximity, decreased depth of field, and eyestrain occasioned by moving closer to the subject. Normal range of loupe magnification in dentistry is 2X to 6X. If Magnification is beyond 5X, loupes tend to become heavy and a microscope would be a better option.

Loupes are classified

A. According to their different optical construction:

Single Lens Loupe: It comprises of simple magnifying lens, which is a diopter and flat plane. A single lens system is made up of one object and one convex, positive, light-converging lens. An image of object is formed when light travels from the object and reaches the lens, which

then focuses the light from the object. The distance of the image of the object from the lens is decided not only by the quantity of divergence of light that is traveling from an object but also by the strength of the lens.

Advantages and disadvantages: The only advantage is that it is the most inexpensive system; however, it is less desirable because the plastic lenses that are used are not always optically correct. Furthermore, the increased image size depends on the proximity with the object being viewed, which can lead to postural problems and create stresses and abnormalities in the musculoskeletal system. They cannot be practically used in dentistry due to size and weight limitations.

Galileian Lens Loupes: It is also known as multi-lens optic system. An enlarged viewing image is produced with a multiple lens system which should be at a working distance between 11 and 20 inches. The Galileian telescope is made up of two lenses; a concave eyepiece lens and a convex objective lens, in which the eyepiece lens has greater strength than the objective lens.

Advantages and disadvantages: In comparison to other compound loupes, these loupes are economical and are simple to operate having only 2 or 3 lenses makes these loupes lighter in weight. However, they create blurry peripheral border of the visual field because of their limited magnification (2.5- or 3.5-fold).

Keplerian loupes: Keplerian also known as Prism loupes are the most optically advanced type of loupe magnification of present era. They are called rooftop or Schmidt prisms as a prism is fixed at the top of it. They provide magnifications up to 6x by using refractive prisms and are actually telescopes with complicated light paths.

Advantages and disadvantages: When compared to any other loupes. Prism loupes provide broader fields of view, wider depths of field and longer working distance.

However, they are heavier and more costly due to increased number of lenses.^[7]

B. On the basis of design

Flip-up loupes

The telescope is mounted further away from the eyes whereas its scope is mounted in front of the lens in a hinge mechanism, which provides a narrower field of vision. It has better declination angle (at which the eyes look down toward the area being worked on) which can be changed according to the user. Forward head movement should not exceed 25° more strain on neck and back muscles occurs if the head is forwarded further. The head position becomes neutral if the declination angle is steeper. Changing the eye prescription glasses does not require demounting the scope and it is heavier than TTL loupes.

Through the lens loupes (TTL)

TTL loupes provide comfort and a wider field of vision as they are positioned closer to the eyes. The scope is mounted on the lens. It is designed specifically for an individual and the angle of declination is set in the factory where they are made. Change in eye prescription requires scope to be demounted to replace the glass. It is lighter and expensive than flip-up loupes.^[7]

Advantages of Loupes

- Small in size, and easy to carry and store.
- No formal training is required and the clinician gets easily adjusted to it.
- Very minimal maintenance required and not as expensive as a microscope.

Disadvantages of Loupes

- With loupes magnification only up to 6X is possible. For higher magnification, microscope is required.
- Image is not stable due to head movements.
- Illumination is not as high as a microscope. Only limited magnification change is possible.

Loupes with higher magnification are uncomfortable on the nose or head due to their large size and increased weight.

- Accessories like beam-splitter, video camera, 35mm camera cannot be attached to a loupe to capture the magnified field.^[8]

Dental operating microscope

The rise of Endodontic microscope is the most vital improvement that occurred in the field of endodontic. The Endodontic microscope not just gives superior magnification from 3x upto 30x, yet in addition enhanced illumination. The Endodontic microscope through its enhanced vision has enormously added to improved surgical and traditional endodontic treatment.

There are various ergonomic alterations to the introduction of the microscope. Maintaining the traditional working positions previously used without the microscope by the clinicians can ensure a possible reduction in consequent stress for the operator. The range of working positions usually ranges from 9 mm to 12 mm.^[9]

The operating microscope comprises of three fundamental components.

The supporting structure: to ensure microscope stability, The supporting structure ought to be mounted on the floor, roof or wall. Reducing distance between the obsession point and the body of the magnifying instrument will build the solidness. The floor mount is ideal in clinical settings with high roof or remote walls.

The body of microscope: It is the most crucial element and consists of eyepieces, binoculars, magnification change factor, and the objective lens.

- a. Eyepiece:** Magnifying the image is the most important function of the operating microscope. The power of eyepiece determines magnification. Eyepieces are usually available in powers of 10x, 12.5x, 16x, and 20x. To adjust the accommodation of

the lens of the eyes, diopter settings should range from -5 to +5.13

- b. Binoculars:** Able to hold the eyepieces with straight, inclined or inclinable tubes.
- c. Magnification changer:** is located within a microscope head and available as a manual changer of 3, 5 or 6 steps, and as a power zoom.
- d. Objective lens:** it determines the working distance between the microscope and the surgical field by its focal length. The focal length is between 100 mm and 400 mm. A 200 mm focal length allows a working distance of about 20 cm, which is generally suitable for use in endodontics.^[9]

The Light Source: It is one of the key highlights and in charge of working in usable fields that are small and profound like the root canal. Xenon 100 watts halogen bulb is its source, whose power is constrained by rheostat and fan-cooled. Illumination and observable pathway share a similar axis, which implies that light is centered between the eyepieces so no shadows will be obvious. Galilean optics make it possible.^[9]

Advantages of operating microscope

(a) Greater operator eye comfort because of the parallel viewing optics of the Galilean system as well as the range of variable magnification, excellent coaxial fiber optic illumination.

(b) Countless accessories such as still and video single lens reflex cameras for case documentation and DVD preparations, co observer tubes for additional viewing by a third assistant, etc.

(c) Magnification allows the surgeon to compare the conventional surgical procedure, which appears as gross crushing and tearing of tissues.

(d) Motor coordination is greatly improved using precision grip instruments, thus reducing tremor.^[10]

Uses of various levels of magnification in endodontics

Adjustments of magnification can be categorized into three levels:

Low magnification (3x – 8x)

Appropriate for examination of tooth orientation and positioning of bur or ultrasonic tip. The wide field of view allows comparisons of the adjacent anatomic landmark. This magnification level is used in loupes in which straightforward cases can still be competently performed.

Medium magnification (8x – 16x)

Commonly used in nonsurgical and surgical endodontic procedures as it provides an acceptable field of view and depth of field. It is used for performing intricate procedures such as perforation repair, separated instrument retrieval and surgical procedure which requires higher precision and accuracy.

High magnification (16x – 30x)

Employed mostly for closeup examinations and inspections of minute anatomies, e.g., calcified canal orifice and minute cracks. Apart from having a diminutive field of view, immediate loss of focus may ensue following minor movements. The subtle color variance between secondary and tertiary dentin in teeth with calcific metamorphosis can be distinguished at this level.^[11]

Advantages of Operating Microscope:

- Improved precision of treatment
- Enhanced ergonomics
- Ease of digital documentation
- Increased ability to communicate through integrated video.^[12]

Disadvantages

There are some disadvantages, especially at the initial stages, most important one is the need for specific training: 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. Other disadvantages include the relatively high initial cost of the equipment and instruments, the need for retraining of the auxiliary staffs, and an adjustment period for the new treatment paradigms and operator postures, may increase treatment costs and reduce initial productivity, besides the need for rescheduling.^[13]

The laws of ergonomics

An understanding of efficient workflow using an OM entails knowledge of the basics of ergonomic motion. Ergonomic motion is divided into 5 classes of motion:

Class I motion: moving only the fingers

Class II motion: moving only the fingers and wrists

Class III motion: movement originating from the elbow

Class IV motion: movement originating from the shoulder

Class V motion: movement that involves twisting or bending at the waist^[15]

Applications

1. In clinical diagnosis

- Cracks and microfracture
- Locating the canal orifices
- Managing calcifying canals
- Intracanal medicament
- Obturation of root canal
- Retrieval of broken instruments

2. In non surgical treatment:

- Removal of post
- Perforation errors
- Final examination of the canal preparation

3. In surgical treatment:

- Isthmus identification and preparation
- Retro preparation

4. In conservative dentistry:

- Caries detection
- Coronal preparation

- Impression quality
- Evaluating the restoration under surface
- Restoration delivery and polish
- Bonded restorations^[12]

Main differences between loupe and dental operating microscope

	Loupe	Dental operating microscope
Cost	Cheaper	Significantly more expensive
Portability	Portable and light Allows practice in multiple locations	Allows practice in multiple locations Floor standing microscopes are portable but take up space and are very heavy to shift While, mounted microscopes are fixed to the ceiling or wall
User adaptability	Easier	Steeper learning curve
Ergonomics	Slight head tilt may be required depending on the degree of lens declination	Perfectly neutral body posture
Level of magnification	Reasonable but fixed and	A higher level of

	limited (2.5× -8.0	magnification is available which can be adjusted (3× -30×)
The line of sight and eye strain	The convergent line of sight leading to eye strain over a long duration of use	A parallel line of sight allowing more relaxed eye muscles. ^[14]

Conclusion

In order to progress in the quality of treatment, the endodontist has been seeking support for new technologies to achieve success.^[16] The increased magnification and illumination have enhanced the treatment possibilities in surgical and non surgical procedures. Treatment modalities that were not possible in the past have become reliable and predictable today.^[17]

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