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THE ROLE OF MAGNIFICATION IN ENDODONTICS

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ABSTRACT:. Until recently, endodontic therapy was performed using tactile sensitivity, and the only way to see inside the root canal system was to take a radiograph. Performing endodontic therapy entailed ''working blind,'' that is, most of the effort was taken using only tactile skills with minimum visual information available. Before the introduction of magnification devices the presence of a problem (a ledge, a perforation, a blockage, a broken instrument) was only ''felt,'' and the clinical management of the problem was never predictable and depended on happenstance. With the recent advances of magnification devices with increased magnification and illumination there is improved technical accuracy and performance. It also allows the dentist to sit in an upright, neutral, and balanced posture, and has proven to be of great value in aiding documentation. This article highlights the role of magnification, types of magnification devices and their clinical application in endodontics.

KEYWORDS: Endodontics, Magnification, Dental Operating Microscope, Oroscope, Optical

INTRODUCTION

Endodontist feels that they can do so much of work blindfolded; simply because there is "nothing to see". There is a great deal in doing endodontic therapy with right tools inorder to achieve good success rate.[1] Magnification is the process of enlarging something only in appearance, not in physical size. This enlargement is quantified by a calculated number also called "magnification".Visualizing the oral cavity has always posed a challenge in dentistry. From early fiber optic lights mounted on handpieces to today's sophisticated procedure scopes, visualization solutions have recently evolved at an unpreceded rate. Dental procedures have become complicated and hence the use of magnification in dentistry has attained a significant position. Clinicians have experienced the increase in the efficiency of dental procedures by using magnification. These advances have enabled clinicians to complete procedures that were once considered impossible or that could be performed only by talented or lucky clinicians. The various magnification devices used are loupes, operating microscope, endoscope and oroscope.

The most commonly used magnification devices are loupes, and even though they enhance visibility of the working field, they have limitations such as convergent vision, deficient magnification, image distortion, colour alteration, small depth of focus, reduced working field, and fatigue caused by extended use.

The most important revolution has been the introduction and widespread adoption of the operating microscope (OM). OMs have been used for decades in other medical disciplines: ophthalmology, neurosurgery, reconstructive surgery, otorhinolaryngology, and vascular surgery. Its introduction into dentistry in the last 15 years, particularly in endodontics, has revolutionized how endodontics is practiced worldwide. It allows amplification of detail, greater versatility in image magnification, excellent visualisation of the working field, the best lighting possible, and a better working posture[2].

Recently the introduction of Endoscopy in endodontics has created a marked change in the precision of dentistry. Endoscopy means looking inside and typically refers to looking inside the body for medical reasons using an endoscope, an instrument used to examine the interior of a hollow organ or cavity of the body. This endoscope is now used in endodontics to visualize the root canal morphology and anatomy [3].

Orascopy is a procedure that uses an orascope for visualization in the oral cavity. Orascopic endodontics is the use of orascopy for visualization in conventional or surgical endodontic treatment. The difference between an orascope and an endoscope is that an orascope utilizes fiber optics and is flexible, whereas the endoscope utilizes rods of glass and is rigid [4].

Need for enhanced vision in Dentistry

Any device that enhances or improves a clinician's resolving power is extremely beneficial in producing precision dentistry. Restorative dentists and endodontists routinely perform procedures requiring resolution well beyond the 0.2- mm limit of human sight. Crown margins, incisions, root canal location, caries removal, furcation and perforation repair, post placement or removal, are only a few of the procedures that demand tolerances well beyond the 0.2-mm limit [1].

Optical principles

Dentists appreciate that the oral cavity is a small place to operate and the size of the available instruments are large. Thus the use of magnification has gained a considerable importance in precision dentistry. The factors responsible to improve the clinical visualization are Stereopsis, Magnification range, Depth of field, Resolving power, Working distance, Spherical and chromatic distortion (ie, aberration), Ergonomics, Eyestrain, Head and neck fatigue and Cost.

As the focal distance decreases, depth of field decreases. Considering the problem of the uncomfortable proximity of the practitioner's face to the patient, moving closer to the patient is not a satisfactory solution for increasing a clinician's resolution. Alternatively, 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.

Loupes

Magnifying loupes were developed to address the problem of proximity, decreased depth of field, and eyestrain occasioned by moving closer to the subject. (Depth of field is the ability of the lens system to focus on objects that are near or far without having to change the loupe position. As magnification increases, depth of field decreases. The smaller the field of view, the shallower the depth of field. For a loupe of magnification 2X, the depth of field is approximately 5 in [12.5 cm]; for a loupe of magnification 3.25X, it is 2 in [6 cm]; and for a loupe of magnification 4.5X, it is 1 in [2.5 cm].)

Loupes are classified by the optical method by which they produce magnification. There are 3 types of binocular magnifying loupes: (1) a diopter, flat-plane, single lens loupe, (2) a surgical telescope with a Galilean system configuration (2-lens system), and (3) a surgical telescope with a Keplerian system configuration (prism roof design that folds the path of light) [5].

1. Diopter system

The diopter system relies on a simple magnifying lens. The degree of magnification is usually measured in diopters. One diopter (D) means that a ray of light that would be focused at infinity would now be focused at 1 meter (100 cm or 40 in). A lens with 2 D designation would focus light at 50 cm (19 inches); a 5 D lens would focus light at 20 cm (8 inches). Confusion occurs when a diopter single-lens magnifying system is described as 5D. This designation does not mean 5X power (ie, 5 times the image size). Rather, it signifies that the focusing distance between the eye and the object is 20 cm (<8 inches), with an increased image size of approximate magnification 2X (2 times actual size)[5].

Advantages and disadvantages: The only advantage of the diopter system is that it is the most inexpensive system. But it is less desirable because the plastic lenses that it uses are not always optically correct. Furthermore, the increased image size depends on being closer to the viewed object, which can compromise posture and create stresses and abnormalities in the musculoskeletal system.

2. Surgical Telescope

The surgical telescope of either the Galilean or the Keplerian design produces an enlarged viewing image with a multiple-lens system that is positioned at a working distance between 11 and 20 inches (28–51 cm). The most used and suggested working distance is between 11 and 15 inches (28–38 cm).

The Galilean system is also called as multi- lens optic system .It produce an enlarged viewing image with a multiple lens system positioned at a working distance between 11 and 20 inches (28-51 cm). The most used and suggested working distance is between 11 and 15 inches (28-38 cm).The Galilean system provides a magnification range from 2x up to 4.5x .It is a small, light and very compact system.

The prism loupes (Keplarian system) use refractive prisms and are actually telescopes with complicated light paths, which provide magnifications up to 6X. It uses five lens and two prisms[4,5].

Advantages: Both systems produce superior magnification and correct spherical and chromatic aberrations, have excellent depth of field, and are capable of increased focal length (30–45 cm), thereby reducing eyestrain and head and neck fatigue. These loupes offer significant advantages over simple magnification eye glasses.

Disadvantages of loupes: The disadvantage of loupes is that the practical maximum magnification is only about 4.5X. Loupes with higher magnification are available, but they are heavy and unwieldy, with a limited field of view. Such loupes require a constrained physical posture and cannot be worn for long periods of time without producing significant head, neck, and back strain.

Ergonomic criteria for loupe selection: Since poorly designed, or poorly adjusted loupes can cause or worsen pain, it is imperative that ergonomic guidelines are considered when selecting loupes.

The 3 most important ergonomic factors to consider when purchasing loupes are

1. Declination angle- The declination angle is the angle created by the eyes being downwardly-inclined to the work area.This angle should be steep enough to help you attain a comfortable working position with minimal forward head posture (less than 25°)
2. Working distance-Working distance is the distance between the eyes and the work area. In scopes with higher magnification, the working range is decreased. To compensate for the natural tendency to drift closer to a working area, it may be necessary to measure the working distance slightly longer than normal, which will give an operator a more flexible working range.
3. Frame size/shape-Large frames that sit low on the cheek will allow lower placement of the TTL scope than smaller oval frames.

Operating microscope

In 1981, Apotheker brought the concept of extreme magnification, in the form of an operating microscope, into dentistry[1]. Four basic advantages in using the operating microscope and accompanying documentation systems (digital microphotography and videography) for private practice include improved precision of treatment, enhanced ergonomics,ease of digital documentation and the increased ability to communicate through integrated video [6].

The operating microscope consists of three primary components [7]

- The supporting structure
- The body of the Microscope,
- The light source.

The supporting structure: It is essential that the microscope be stable while in operation, yet remain manoeuvrable with ease and precision, particularly when used at high power. The supporting structure can be mounted on the floor, ceiling, or wall. As the distance between the fixation point and the body of the microscope is decreased, the stability of the set up is increased. In clinical settings with high ceilings or distant walls, the floor mount is preferable. Although it is stated that it can be easily moved from one operatory room to another, in fact, it is very cumbersome to do this and is a very ineffective way to use a microscope.

The Body of the microscope: The body of the microscope is the most important component of the instrument and it contains the lenses and prisms responsible of magnification and stereopsis. The body of the microscope is made of eyepieces, binoculars, magnification changer factor, and the objective lens.

Eyepieces are generally available in powers of 10x, 12.5x, 16x, and 20x.The most commonly used are 10x and 12.5x.The end of each eyepiece has a rubber cup that can be turned down for clinicians who wear eyeglasses. Eyepieces also have adjustable diopter settings. Diopter settings range from -5 to +5 and are used to adjust for accommodation, which is the ability to focus the lens of the eyes.

The binoculars contain the eyepieces and allow the adjustment of the interpupillary distance. Their focal length is 125 or 160 mm. They are aligned manually or with a small knob until the two divergent circles of light combine to effect a single focus. Binoculars are available with straight, inclined, or inclinable tubes. Straight tube binoculars are orientated so that the tubes are parallel to the head of the microscope. They are generally used in otology and are not well suited for dentistry. Inclined tubes are fixed at a 45° angle to the line of sight of the Microscope .The inclinable tubes are adjustable through a range of angles and allow the clinician to always establish a very comfortable working position. It is therefore obvious that, even if more expensive, the inclinable binocular is always to be preferred.

Magnification changers are available as 3-, 5-, or 6-step manual changers, or a power-zoom changer. They are located within the head of the microscope. Manual step changers consist of lenses that is connected to a dial located on the side of the microscope. The magnification is altered by rotating the dial.

The objective lens is the final optical element, and its focal length determines the working distance between the microscope and the surgical field. The range of focal length varies from 100 mm to 400 mm. A 200 mm focal length allows approximately 20 cm (8 inches) of working distance, which is generally adequate for utilization in endodontics. The objective lens, as well as all the other lenses of the microscope (eyepiece lenses, magnification lenses,camera attachment lenses, etc), all have several layers of an anti-reflective coating on both surfaces, which reduces return light loss from normally 2% per lens surface to only 0.5% per lens surface.In other words, the coating is used to absorb only a minimum amount of light in order not to decrease the illumination of the operative field.

The total magnification (TM) of a microscope depends on the combination of the four variables:

-Focal Length of Binocular (FLB)
-Focal Length of Objective Lens (FLOL)
-Eyepiece Power (EP)
-Magnification Factor of the changer (MF).

The total magnification can be represented by the following formula[8]

TM = (FLB/FLOL)xEPxMF

The Light Source: The light source is one of the most important features of an operating microscope. Besides optics, the light source is responsible for operating in operative fields that are small and deep like the root canal. This is possible because the microscope provides a powerful coaxial illumination, which means that the light is coaxial with the line of sight and eliminates the presence of any shadows. The light source is generally powered by a 100- to 150- watt halogen light bulb that is connected to the microscope with a high efficiency fiber-optic cable. The light passes through a condensing lens, a series of prisms, and then through the objective lens to the surgical site. The intensity of light is controlled by a rheostat.

Accessories: In order to deflect a certain percentage of the light from the eyepiece towards the accessories, a beam splitter can be placed between the binoculars and the magnification changer. The beam is generally split at a 50:50 ratio (ie. half of the light is always available to the operator).A photo or video adapter can be connected to the beam splitter. The video camera is a useful adjunct and serves two additional purposes: it allows the assistants to follow the procedure precisely and assist efficiently, and it can also be used for documentation using video prints or recordings.

The Law of Ergonomics: An understanding of efficient workflow using an OM entails knowledge of the basics of ergonomic motion[1]. 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

Advantages of Operating Microscope:

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

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:**
    - -Isthumus 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

Endoscope

First endoscopic light should be credited to Tulio caesare Aranzi (1585) wrote of using solar rays entering a small hole placed in a window shutter. H.H Hopkins in1951 introduced a new telescopic lens system. It has 4 components a telescope with camera head light, a light source, a camera and a monitor.

The use of rod lens endoscope in endodontics was first reported in 1979. In 1996 the rod lens was recommended as magnification instrument for conventional and surgical microscope. Rods of glasses working in a junction with a camera, light source and monitor. Digital recorder (still capture or streaming video) can be added to it for documentation. The endoscope can be used as a visualization instrument for conventional endodontic treatment, it can be bulky and difficult to maintain a fixed field of vision[9].

For surgical endodontics, the recommendation was to use an endoscope that is 6 cm in length with a 4.0-mm diameter lens and a 30° angle. Since that time (1996), technological advances have yielded smaller endoscopes with increased angulation. Prior to the introduction of these new devices, short endoscopes were fragile, and when the angulation was increased beyond 30°, the images had a fish-eye appearance. Today's endoscopes are shorter, and when the lens is angled beyond 30°, the fish-eye effect is not present [9,10].

Endoscope has 2.7mm lens diameter, 70 degree angulations, 3 cm length rod lens (both surgical and conventional endodontic treatments). It should be noted that there are many different scope lengths, lens angulations, and diameters in the medical market.The aforementioned endoscopes best fit the ergonomic and logistical considerations for endodontic visualization.

Oroscope

Bahcall and Barss first reported on the use of orascopic visualization in 1999. Orascopic endodontics is the use of orascopy for visualization in conventional or surgical endodontic treatment [4,11].

The orascope and endoscope work in conjunction with a camera, light source, and monitor. Currently, only one orascope visual system is available for dental usage, manufactured by Jedmed .The option of a printer or digital recorder can be added to the system for documentation purposes.The image quality has direct correlation with the number of fibers & size of lens used[12].

Orascope has a 0.8mm tip diameter, 0 degree lens & 15mm length. It is made up of 10,000 parallel visual fibers (3.7 & 5 microns diameter). A ring of larger, light transmitting fibers surround the visual fibers for illumination of the treatment field.

Oroscopic visualization technique for conventional endodontic treatment: Once the soft tissue has been removed from the pulp chamber, the 4-mm-lens-diameter, 70° endoscope can be used to examine the pulpal floor when it is necessary to have higher magnification during conventional endodontic treatment. The clinician holds the endoscope instead of the dental mirror when using instrumentation or during examination of a conventional endodontic field. When using an instrument or handpiece in conjunction with the endoscope, it is recommended that the endoscope be stabilized by resting it on a cusp tip. If this is not possible due to tooth morphology, a rest in the enamel can be created with a high-speed handpiece and bur.

The 0.8-mm orascope is used to visualize within the canal system.The small fiber-optic size enables the orascope to actually go down into a canal. Prior to the placement of the 0.8-mm fiber-optic scope, the canal must be prepared to a size No. 90 file in the coronal 15 mm of the canal. If the canal is not instrumented to this diameter, a wedging of the probe may occur, damaging some of the fibers within the scope. Appropriate preparation also allows the full 15 mm of the orascope to penetrate within the canal.

If a canal is curved, the orascope may not be able to visualize around the curve because of limited flexibility. Also, if the canal is not properly prepared to a size No. 90 file in the coronal 15 mm of the canal, the orascope will not be able to be placed properly within a canal; hence, intracanal visualization will be hindered. The focus and depth of field of an orascope is zero mm to infinity.This allows the orascope to provide imaging of the apical third of the root without actually having to be positioned within this region of the canal.

It is important to note that the canal must be dried prior to usage of the 0.8-mm scope. Although the orascope can be used when sodium hypochlorite is present in the canal, this solution has a high light refractory index. This will result in difficulty visualizing details within the canal. Further, the intracanal environment is relatively warm and humid.Temperature and humidity differences between the dental operatory and the canal can result in moisture condensing on the orascope lens, resulting in fogging. The use of a sterile antifog solution (Jedmed) eliminates this problem.

Oroscopic visualization technique for surgical endodontic treatment: The 2.7-mm-lens-diameter, 3-cm-length-rod-lens, 70° endoscope are recommended for visualization during surgical endodontic procedures. Prior to placement of a scope, hemostasis within the surgical field must be obtained, since discernible images are not possible if blood is present. As with the orascope, an antifog sterile solution is placed over the lens of the endoscope to help prevent condensation from occurring.

Methylene blue stain can be used in conjunction with visualization instruments during surgery .This stain helps the clinician identify the etiology of the lesion; the defect stains a bluish color, which allows for enhanced visualization with the endoscope. As with conventional endodontic orascopic application, the clinician should hold the endoscope while the assistant retracts gingival tissue and suctions during the surgical procedure. The 70° angle enables the endoscope to image the resected end(s) of the root(s). It is not recommended to use the endoscope also to retract gingival tissue. This will inhibit free movement of the endoscope[13].

Documentation of procedures: The recent technological advancements in digital recording have allowed high-quality, digital record-keeping of procedures accomplished with an orascope or endoscope. The digital recordings demonstrate minimal degradation over time, and high-quality paper images can be selectively printed using a digital printer.

CONCLUSION

The use of magnification has quietly become the standard of care, as it keeps showing a frank superior result in all restorative techniques, with consequent increase in the longevity of restorations. The introduction of the magnification devices in dentistry, particularly in endodontics, has been a significant addition to the profession's armamentarium. The increased magnification and illumination have enhanced the treatment possibilities in surgical and nonsurgical procedures. Treatment modalities that were not possible in the past have become reliable and predictable [14].

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