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Enhancing precision - Magnification and Resolution in Endodontic Microscopy

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Abstract

In the history of dentistry, the introduction of the dental microscope was a turning point; it led to a rapid shift from the conventional world of macro dentistry to the precise detailed world of micro dentistry. The introduction of the microscope has brought about significant changes in how endodontic procedures are performed which has transformed the field. The microscope helps in providing better magnification from 3x up to 30x and better illumination. By providing enhanced visualization capabilities at a microscopic level, these instruments have empowered clinicians to perform intricate procedures with greater accuracy and precision. Microscopes have contributed to improved surgical as well as conventional treatment through their enhanced vision. The infinity-corrected optics of an Operating Microscope enable parallel vision, which results in the same relaxed visual sensation as that experienced when looking into the horizon, rather than requiring eye convergence as observed with loupes or even the naked eye. The quality of illumination offered by an Operating Microscope is considered equally crucial to its magnification in terms of enhancing image resolution.

This review aims to examine the importance of magnification and resolution in endodontic microscopy, including the range of magnification levels commonly used and their impact on visualization and precision during treatment.

Keywords: Microscope, magnification, resolution, visualization, precision

Introduction

The introduction of the operating microscope (OM) is one of the greatest advancements in dentistry, significantly enhancing clinical efficacy across various treatment procedures.[1]

The introduction of the microscope in dentistry dates back to five decades. According to the Zeiss Company, the microscopes were initially adopted in otolaryngology around 1950, followed by neurosurgery in the 1960s, and later in endodontics in the early 1990s. Therefore, dentistry lagged almost four decades in incorporating this technology. The integration of microscopes in clinical endodontics has significantly transformed the practice, fundamentally altering the approach to endodontic procedures.[2]. Gary Carr in the early 1990s introduced OM in Endodontics, serving as the foundation for subsequent authors to deepen its application in dentistry. Apotheker introduced the dental operating microscope in 1981.[3]The initial model was poorly configured and presented ergonomic challenges. Its integration into that field significantly influenced the practices of endodontists, prompting the American Dental Association in 1998 to advocate for the inclusion of microscope usage in both nonsurgical and surgical endodontic training across all graduate programs in the United States.[4]

Higher visual acuity appears to be demanded by clinicians managing intricate cases in endodontics due to the narrow operating space and the minuscule anatomy involved. Magnification in endodontics has proven invaluable in numerous scenarios, significantly influencing decisions regarding the salvage of teeth previously deemed non-restorable. Enhanced vision and illumination enable various critical tasks, including Diagnosing caries and minute cracks, Performing conservative access openings, Identifying obscure anatomy, Managing calcified canals, Confirming canal cleanliness before obturation, Outlining and removing pulp stones, Addressing perforations and tooth resorption, Retrieving silver points, separated instruments, and fractured posts, Conducting smaller osteotomies, magnified inspections of resected surfaces, as well as retro preparation and retro filling in endodontic microsurgery.5The primary utility of the microscope in nonsurgical endodontics lies in its ability to locate hidden canals.

Achieving excellence in the field of endodontics involves a deliberate decision and an ongoing process, wherein the utilization of magnification can significantly enhance the pursuit of precise clinical outcomes.[6]Among practitioners, the approach to training and its intensity might differ. Training methods include independent study, involvement in residency programs, and participation in formal training sessions. Berezniak, emphasized the importance of mastering microsurgical techniques in a laboratory setting before applying them in the operating theater.[7]

This aim and objective of this article to examine the importance of magnification and resolution in endodontic microscopy, including the range of magnification levels commonly used and their impact on visualization and precision during treatment.

Materials and Methodology

To review the literature, Studies were selected from PubMed, Scopus, Web of Science, and Google Scholar with restrictions on publication year, to provide a comprehensive overview of current knowledge on magnification and resolution in endodontic microscopy. The review focused on examine the importance of magnification and resolution in endodontic microscopy, including the range of magnification levels commonly used and their impact on visualization and precision during treatment. The search terms included: “Microscope,” “Magnification,” “Visualization,” “precision,” “Endodontics,” “Resolution,” and “Visual aids.” The research encompassed, Case reports,

laboratory studies, clinical studies, and literature reviews.

Dental Operating Microscope

The operating microscope, equipped with a digital camera, which facilitates clear visualization of the surgical operating field, enabling precise differentiation between bone and root structures, thorough examination of fractures, and accurate removal of granulation tissue, apical root canal preparation and retrograde obturation. The most minute details of the operating field can be captured by these microscopes, facilitating the documentation of patient information, providing explanations, and supporting subsequent research studies and better working field .[8] the operating microscope in dentistry is based on Galilean principles.[10]

The basic components of operating microscopes are

- **The supporting structure** - To ensure the stability of the microscope, it's essential to mount the supporting structure on the floor, ceiling, or wall. Decreasing the distance between the fixation point and the microscope body increases stability. In clinical setting with high ceilings or distant walls, a floor mount is typically preferred.[9]
- **Microscope body** – It is the most vital component comprising of eyepieces, binoculars, magnification alteration factor, and the objective lens.[9]

Eyepiece

Magnifying the image is the primary function of the operating microscope. The magnification is determined by the power of the eyepiece, typically available in the power of 10x, 12.5x, 16x and 20x. To accommodate the lens of the eyes, diopter settings should range from -5 to +5.[9]

Binoculars

These microscopes come with straight, inclined, or inclinable tubes, each equipped with provisions for holding the eyepieces.[9]Only inclined, swiveling tubes are used in dentistry which permit continuously adjustable viewing. Moreover, they improve ergonomics by enabling operators to adjust the tubes without altering their head, neck, or back posture.[10] Interpupillary distance refers to the adjustment of the distance between the two binocular tubes. These tubes can be adjusted either inward or outward, depending on the pupillary distance of the individual using the microscope.[8]

Magnification Alteration Factor

It is located within the microscope head.[9]

The magnification changer comprises of 1. Manual changer (3, 5, or 6 steps) 2. Zoom changer[8]

The manual changer features a turret fixed lens with a dial located on the side of the microscope. Adjusting the position of the dial alters the first magnificationfactor. Rotating the dial, this in turn, reverses the lens position, producing the second magnification factor. A 5-step magnification changer combines the eye piece power, focal length from two pairs of lenses, and a blank space in a lens-less turret.[8]

The zoom changer, available in manual or power variants, adjusts the magnification factor. In a manual zoom changer, a sequence of lenses on a focusing ring moves back and forth to adjust magnification. The power zoom changer is a mechanical version with added foot control for hands-free magnification adjustment. Zoom changers aim to eliminate the momentary optical interruption caused by rotating the turret for magnification changes.[8]

Objective Lens

It represents the ultimate optical element. The focal length dictates the working distance between the microscope and the surgical field, which ranges from 100 mm to 400 mm. A 200 mm focal length provides

around 20 cm of working distance, suitable for endodontic procedures. Antireflective coating ensures minimal light absorption, maintaining adequate illumination of the operative field.[9]

Light source- This key feature is essential for operating in the deepest portions of the root canal. Coaxial illumination is essential, ensuring that light enters the canal at any angle but remains perfectly aligned with the operator's view, thus preventing shadows.[8] Surgical microscopes typically utilize three main types of illumination: incandescent, halogen, and fiberoptic. Halogen lamps offer a whiter light compared to conventional bulbs due to their higher color temperature. Xenon lamps, an alternative option, boast a lifespan up to 10 times longer than halogen lamps. They provide light with daylight characteristics, resulting in exceptionally bright images with sharper contrast. [10]

Figure 1: Body of the Microscope [10]

Magnification

The naked eye can only perceive objects up to canal orifices. Additionally, natural vision starts declining around the age of 40.[5]

Before the use of operating microscope, endodontic therapy relied solely on tactile sensation. This approach meant practitioners often worked without direct visual guidance, relying predominantly on their tactile skills, identifying issues such as ledges, perforations, blockages, or broken instruments was primarily based on a sense of touch, making clinical management unpredictable. The procedure due to visual limitations demanded exclusive tactile dexterity, mental visualization, and persistence from the dentist.[3]

The magnification is determined by i. Eye pieces – are available in a range of magnification powers – 6.3X, 10X, 12.5X, 16X and 20X. ii. Magnification changer and iii. Objective lenses.[11]

Magnification ranges used in surgical and non surgical endodontics can be classified as follows:

1. **Low magnification (×3–×8)** is typically employed in

- Loupes for straightforward cases. It facilitates:
- Comparison with adjacent anatomic landmarks
- Examination of tooth orientation and positioning of the ultrasonic tip or bur.[8]

2. **Medium magnification (×8–×16)**

This is the most commonly used magnification in endodontics.

- Identify root canal orifice
- Suitability for tasks such as identifying, preparing, filling, and resecting the root tip
- Application in obturation, root surface analysis, fracture diagnosis, and hemostasis and tissue removal
- Provides an acceptable field of view and depth of field, making it ideal for intricate procedures like perforation repair, separated instrument retrieval, and surgical interventions demanding higher precision and accuracy.[8,5]

3. **High magnification (x16-x30)** is primarily utilized for close-up examinations and inspections of minute anatomies, such as:

- Identifying calcified canal orifices and minute cracks
- Inspecting subtle color variances between secondary and tertiary dentin in teeth with calcific metamorphosis
- The molars are examined for an additional canal, more than 50 percent of 1st maxillary molar have a fourth canal.[11]
- Inspection of amputation, preparation and filling[12]

Offering a diminutive field of view, with the risk of immediate loss of focus following minor movements.[8,5]

Total Magnification

Given by Khayat as:

TM = (FLT/FLOL) × EP × MV

TM = total magnification

FLT = focal length of the tube

FLOL= focal length of the objective lens

EP=eyepiece power

MV=magnification value [13]

Resolution

The human naked eye has a resolution power of 0.2mm. This means that when lines or points are 0.2mm apart, it is likely to appear as a single line or point to most people. As the distance between them decreases to 0.1 mm, it becomes challenging for most normal eyes to distinguish these closely spaced entities.[14]However, many endodontic procedures demand precision far below the resolution the human eye is capable of. Therefore, magnification is essential for performing minimally invasive treatments.[15]

With the help of operating microscope, the resolving power can be increased from 0.2mm to 0.006mm or 0.6µm, a significant enhancement of the viewed structure.[14]

Advantages of Dental Operating Microscope

1. **Increased visualization**

Improved visualization helps in better quality, precision and better treatment prognosis. If you can see it, you can treat it.[16]The uncertainty in clinical diagnosis decreases with better visibility.[17] It facilitates easier diagnosis of enamel infraction, enamel cracks, initial dental caries, microleakage and soft tissue lesion.[5,17] It can be used in routine dental procedure to identify and locate canal orifices such as MB2 in maxillary molars or C-shaped canals in mandibular molars. It helps in detecting perforations in the canal floor, identify calcified canals which are difficult to find, and provide clear visibility for retrieving posts or fractured endodontic instruments from root canals. This helps to enhance the overall treatment quality significantly.[17,14]

Endodontic microsurgeries, performed under the microscope provides various benefits, as it minimizes trauma to the surgical site and reduces the risk of damaging adjacent structures.[5]

2. Improved Ergonomics

While working with a microscope, understanding efficient work flow involves familiarity with the fundamentals of ergonomic motion, which are categorized into five classes.

- Class I – movement of fingers only
- Class II – movement of fingers and wrists only
- Class III – movement arising from elbow
- Class IV – movement arising from shoulder
- Class V – movement involving twisting at the waist.[12]

The central ergonomic principle in a microscope-centered practice is known as the "circle of influence." This principle emphasizes that all essential equipment

and supplies required by both the doctor and assistant should be positioned within arm's reach of either, ideally requiring no more than a Class III motion to access. [3]

Good ergonomics allow longer working time without repetitive muscle strain.[19]

3. Documentation

Documentation provides image information that can be shown to patients and also used for educational purposes. Documentation can be obtained by using a still camera(35mm film or a CCD camera) or a video camera.[20] The integrated video helps in communication skills.[9] integration of dental operating microscope with new digital technologies not only helps in documenting our daily work but also helps to communicate with colleagues, staff, and patients for the future.[21]

It can also be of help in a medicolegal case.

Disadvantages of Operating Microscope

1. The high cost of setting up a microscope.
2. Learning curve - Adapting to higher magnification devices poses a steeper learning curve, particularly for senior dentists with eyesight challenges. Those accustomed to loupes may find transitioning to microscopes less demanding due to similar device setups. However, mastering hand-eye coordination for endodontic procedures under indirect vision requires practice to orient canals correctly. Precise movements are crucial at mid- to high-level magnifications, as minor tremors become more pronounced. To ease initial discomfort, starting with lower magnifications like ×2.5 or ×3.0 is advisable, gradually increasing as comfort grows. Regular breaks and experimenting with different magnification designs can aid in selecting the most suitable equipment.[5] Moreover, because working under a microscope effectively involves working with "four hands," it is essential to motivate and properly train the dental assistant.[3]
3. Its size makes it challenging to fit into small operating space.
4. It offers a narrower field of vision.[9]
5. One challenge encountered when using magnification is the risk of cross-contamination, as well as the potential for lens scratching.[5]

Conclusion

In conclusion, operating microscope represent a significant advancement in dental practice, offering enhanced magnification and resolution as compared to naked eyes which leads to improved precision and treatment outcomes. But their integration into everyday dental clinics still poses challenges, the substantial investment required, extended set up time, the necessity for comprehensive training for dentists and dental assistants underscore the current barriers. Nevertheless, with advancement in technology and practitioners more familiar with their capabilities, the operating microscope stands to revolutionize endodontics and other dental specialities in the future, promising even greater advancement in patient care and treatment prognosis.

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