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Magnification in endodontics: A review

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***Abstract*---**Over the past few decades, technological advances in endodontics have taken quantum leaps from conventional hand files to rotary system and from direct vision to magnification. Magnification helps the user not only to see more, but to see well. The application of magnification devices in endodontics is mainly meant for visual enhancement and improved ergonomics. This is crucial especially when long hours are spent in a narrow operating space to treat obscure microanatomy. Magnification aids assist in producing higher quality procedures due to better precision and accuracy. Using the microscope aids improved ergonomics for the operator. Using loupes or microscopes improves the clarity in treatment plan as well as its execution. The magnification aids with camera and video monitor attached, enhance the patient education and better documentation. A strong consideration should be given to adopt using the concept of magnification. Nevertheless, application of magnification in dentistry has yet to be introduced into the mainstream practice due to various influences in behavioural patterns. This review intended to explain the significances of magnification in the field of endodontics as well as use of these tools in dental procedures for better accuracy, handling and thoroughness, which will lead to fewer procedural errors.

***Keywords*---**magnifying glass, loupes, microscope, orascope, endoscope.

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Introduction

The field of endodontics has witnessed significant technological advances over the past few decades. One area of advancement has been the evolution of endodontic visualization. The endodontists have always pursued to improve the vision of the operating field. The human naked eye with a resolving power of 0.2 mm is capable of distinguishing fine detail when an image is sharpened and enlarged to effectively magnify the area of interest for proper diagnosis and treatment of various dental pathologies.[1] The concept of magnifications for microsurgery was introduced to medicine during the late 19th century.[2] Carl Nylen, who is considered the father of microsurgery, first used a binocular microscope for ear surgery in 1921. The pioneers in dentistry were Apotheker and Jako, who first introduced the use of microscope in dental procedures in 1978.[3] Following this, Carr, in 1992, published an article defining and emphasizing the role of the surgical microscope in endodontic procedures.[4] In 1994, Shanelec and Tibbetts presented a continuing education course documenting the use of surgical microscope in dentistry and called it "Microscope‑Assisted Precision Dentistry."[5]

Over the years, many magnification devices have been introduced as bridging tools between the naked eyes and the microscope. In fact, tools, such as an endoscope, magnifying glass, and intraoral camera, have largely been superseded by contemporary devices that seem to be more practical and convenient for application, such as loupes and dental operating microscope (DOM). [5] This review describes several common types of magnification devices applied in the discipline of endodontics, the factors that influence their adoption, the advantages, and shortcomings, as well as the importance of using magnification devices for endodontics.

Types of magnification devices in dentistry

The modern-day dentist has numerous magnification systems to choose from. These magnifying systems range from simple loupes to compound prism telescopic loupes and the vast variety of surgical microscopes. Each magnification system has its advantages and also its limitations. [6]

Magnifying Glasses

A magnifying glass is a double convex lens mounted in a frame with a handle . A magnifying glass works by creating a magnified virtual image of an object behind the lens. This happens only when the distance between the lens and the object is shorter than the focal length of the lens. Magnifying glass has a focal length of 25 cm and an optical power of 4 diopters. Such a magnifier is available as a "2×" magnifier.[7]

Loupes

Loupes are the most common magnification system used in dentistry. These are fundamentally two monocular microscopes, with side-by-side lenses, angled to focus an object.

Based on optical construction[8]

- Simple loupes
- Compound loupes
- Galilean loupes
- Prism loupes.

Based on design

- Flip-up loupes
- Through the lens loupes (TTL) [8]

Simple Loupes

Simple loupes consist of a pair of single, positive, side-by-side meniscus lenses. Each lens has two refracting surfaces, with one occurring as light enters the lens and the other when it leaves. Its main advantage is that it is cost effective. The disadvantages are it is primitive with limited capabilities and are highly subjected to spherical and chromatic aberrations, which distort the image of the object. [8]

Compound Loupes

Compound loupes have an array of convergent multiple lenses. There are air spaces in between these lenses which gives an additional refracting power, magnification, working distance, and depth of field. Such loupes can be easily adjusted as per the clinical requirements by lengthening or shortening the distance between the lenses. Compound lenses can be achromatic, and this feature is to be given importance while selecting a dental loupe. These achromatic lenses are efficient in producing a colour perfect image. [8]

Prism Loupes

Prism loupes are optically most advanced containing Pechan or Schmidt prisms that lengthen the light path through a series of mirror reflections within by virtually folding the light so that the barrel of the loupe can be shortened. They produce better magnification, larger fields of view, wider depths of field, and longer WDs. This is a feature that dentists should seek when selecting any magnifying loupe because an achromatic lens consists of two glass pieces, usually bonded together with clear resin. The specific density of each piece counteracts the chromatic aberration of the adjacent piece.[8]

Galilean Loupes

These loupes are cheap and are simple to operate while compared to other compound loupes. These loupes consist of only 2 or 3 lenses which make them light in weight and also inexpensive. Their only disadvantages are limited magnification (2.5- or 3.5-fold) and a blurry peripheral border of the visual field.[9]

Based on 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 a better declination angle (at which the eyes look down toward the area being worked on) which can be changed according to the user. The head position becomes neutral if the declination angle is steeper. Flip-up loupes are heavier than TTL loupes.[10]

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.[11]

Surgical Operating Microscope

In dentistry, operating microscopes are designed on Galilean principles. The operating microscope has now fundamentally and radically changed the way endodontic procedures and surgeries can be performed . The microscope provides better magnification from 3× to 30× and better illumination. It is beneficial for the clinician and the patients in terms of ergonomics, clear vision, better prognosis, minimal appointments, and economical.[12] The operating microscope consists of three basic components- 1)the supporting structure 2) the body of microscope, 3)the light source

Supporting Structure

The microscope must 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. [11]

The body of the microscope

It is the most crucial element and consists of eyepieces, binoculars, magnification change factor, and the objective lens.[11]

a. Eyepiece: Magnifying the image is the most important function of the operating microscope. The power of the 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.[11]

b.Binocular Tubes:
They can be straight or inclined depending on the use. In dentistry, only inclined, swiveling tubes that permit continuously adjustable viewing are used. Further more, they improve the feasibility for improving ergonomics

as the operator can adjust the tubes without changing his head, neck, or back posture. [12]

c. Magnification Changer

It is situated within head of the microscope and is available as 3-5-, or 6-step manual changer, or a power zoom changer. [12]

d. Objective Lens

Focal length of the objective lens determines the working distance between the microscope and the operating field. The focal length ranges from 100 mm to 400 mm. Ideally, when the focal length is 200 mm there is 20 cm/8 inches of working distance. This distance is ideal for endodontic procedures. A layer of antireflective coating ensures absorption of minimum light to maintain the illumination of the operative field. [13,14]

Lighting unit

In surgical microscopes, incandescent, halogen, and fiberoptic are the principal types of illumination. Halogen lamps provide a whiter light than lamps using conventional bulbs due to their higher color temperature. Other options available are the xenon lamps, which function up to 10 times longer than halogen lamp. The light has daylight characteristics with an even whiter color, which delivers exceptionally bright images with sharper contrast. [15,16]

Figure : Body Of The Microscope

Recent advancement in magnification

Zeiss OPMI PROErgo

It has a feature of motorized/foot-controlled adjustment of focal length. This causes the least disturbance and optimal ergonomic work even when treatment continues for several hours.[17]

Mechanical Optical Rotating Assembly Interface (Mora Interface)

It is a mechanical optical rotating assembly that connects the binocular tube at a right angle to the body of the operating microscope making it capable of a limited independent rotation around the horizontal axis of the binocular tube. This was devised to overcome the drawbacks of conventional microscopes which were designed to allow the clinician to sit at the 9–10 o’clock position. This led to an inclined neck position toward the right shoulder, leading to overextension of the left arm, muscle tension, fatigue, and disability. This technology enables the operator to be seated at 12 o'clock position, providing a horizontal WD that is compatible with the distance between the head and the mouth of the patient.[17]

Head -Mounted Microscope

It has a magnification range of 2.9× to 7.0×. Its working distance is 11.81–27.56 inches. It is autofocus and has an integrated autofocus camera. It also has integrated light optics. Its field of view is 1.18–8.82 inches and has a shadow-free illumination.

Advantages Of Microscope

a) Higher magnification
b) Better illumination
c) Superior optical properties
d) Galilean optics reduces the need to have the eyes converge to focus and thereby reduces eye strain and fatigue.[18]

Disadvantages Of Microscope

a) Occupies a lot of space.
b) Bulky instrument. [19,20]
c) Training regarding its parts and usage is a must before surgery.
d) Expensive.
e) Requires high maintenance.[19,20]

Optical Principles Of Magnification Devices

An increase in magnification decreases the focal depth. Wearing loupes, especially at magnifications higher than ×4, requires the practitioner to stay in a narrow range from the object to stay in focus. In contrast, even at high magnifications, a microscope remains stable and the practitioner can work in an upright and ergonomically non-stressful position.[13] Moreover, microscope use reduces strain on eye muscles, fatigue, and soreness compared to loupes. Through a microscope the light reaching the left and right eyes appears to be essentially parallel, achieving the effect of far distance observation and avoiding short accommodation stress as with the naked eye.[14]Binoculars of loupes and thus the viewing direction are convergent, resulting in similar eye strain. In addition, microscopes provide imaging virtually free of shadows, allowing excellent image quality for clinical operations and documentation.[15]

Total Magnification Formula By Khayat[16]

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

Recent Advances In Magnification

Orascope

An orascope is a fiber optic endoscope designed for intracanal visualization . Fiber optics is small, lightweight, and flexible plastic. The image quality has a direct correlation to the number of fibers and size of the lens used. Orascope is made of 10,000 parallel visual fibers. The visual fiber is between 3.7 μm and 5.0 μm in diameter. Orascope has a 0.8-mm tip diameter, 0° lenses, and a working portion of 15 mm in length.[17]

Rod Lens Endoscope

Rod lens endoscope provides greater magnification than loupes. It consists of rods of glass. It has a camera, a light source, and a monitor. Disadvantage of rod lens endoscopy is that the instrument is rigid, so it cannot be used in visualizing curved root canals.[18] 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 iskml rigid. The orascope is used to visualize within a root canal system, while the endoscope is used to visualize canal access in conventional endodontic therapy and in surgical endodontic treatment. The orascope and endoscope work in conjunction with a camera, light source, and monitor. The option of a printer or digital recorder can be added to the system for documentation purposes.[19] A 2.7-mm-lens-diameter, 70° angulation, 3-cm-length-rod-lens endoscope and a 4-mmlens diameter,30° angulation, 4-cm-lengthrod-lens endoscope are both used for surgical endodontic visualization. The aforementioned endoscopes best fit the ergonomic and logistical considerations for endodontic visualization. The latter configuration (4-mm-lens-diameter, 30°angulation, 4-cm length rod lens endoscope) is also used for conventional endodontic visualization.The fiber-optic orascope used for intracanal visualization has a 0.8-mm-tipdiameter, a 0° lens (a flat lens that does not have any angulation), and the working portion is 15 mm in length. The orascope has 10,000 parallel visual fibers. Each visual fiber is between 3.7 and 5 μm in diameter.To allow for illumination of the treatment field, a ring of larger, light-transmitting fibers surrounds the visual fibers. [20,21]

Uses Of Magnification

a) Examination, diagnosis, and treatment planning:
   Demineralization around the grooves and tiny amounts of flaking of darkened carious tooth structure within the crevices of these grooves can be appreciated with magnification, which can be a vital element in diagnosis and deciding the treatment plan. [22]
b) Diagnosis of cracked teeth :
   Cracks in teeth or restorations, craze lines, wear facets, cracks at slightly elevated marginal ridges can be appreciated under magnification.[23]
c) Better visualization of the pulp chamber, canal orifices : Magnification aids in Better visualization of anatomical landmarks, within the pulp chamber—

including the sides, overhanging remnants of the pulp chamber roof, initial perforations into the pulp, dentinal map, canal orifices and to differentiate between the pulp horns and the main body of pulp within the chamber.[24]

d) Cleaning and shaping :

The improved ability to see specific canals allows endodontists to manoeuvre files into canal openings with greater efficiency. To determine if all canals are accessed and instrumented properly when a direct view might be difficult without removing excessive amounts of coronal tooth structure.[25]

e) Identifying obscure anatomy :

Anatomical variations are not as rare or exotic as is frequently assumed. The introduction of the dental microscope and the associated ability to inspect the root canals have shown better results in detecting the hidden canals .[26]

f) Identification and removal of Denticles:

This specific form of calcification is also encountered very frequently, can block the canal entrance or even obstruct further instrumentation. Denticles can be found and negotiate readily with the help of a dental operating microscope and ultrasonics tip.49 An ultrasonic tapered and active tip Start-X™ #3 (Dentsply Maillefer) was introduced to remove the calcific obstruction. The entire mass could be dislodged from the walls of the pulp chamber and its underlying attachment.[27]

g) Effective Obturation:

Proper illumination and magnification aids to visualize the space in the root canal system. During obturation, this helps us to achieve the ideal apical seal. Root canal sealers can be better placed under magnification, such a uniform coating of root canal walls can be achieved.54 While performing sectional obturation and using thermoplasticized guttapercha, use of DOM is a very helpful aid.[28]

h) Management of open apex :

The main goal of this procedure is to control the bacterial infection and establish a suitable environment for the induction of calcified tissue into the apical area. Manipulation of modern apexification therapies for special treatment techniques and materials has been facilitated significantly under a dental microscope. The dental operating microscope has aided tremendous improvements in visual acuity of the open apex and hence has made it possible to provide proper sealing using an apical barrier. The use of an operating microscope allows better control of the placement of the MTA apical plug.[29]

i) Retrieval of Fractured Posts and Instruments:

Due to enhanced vision with magnification and illumination, the Dental operating microscope allows to detect of the proper location of the fractured post and broken instruments and to remove them minimal loss of healthy tooth structure.[30]

j) Microsurgical Endodontics:

In the early 90's microscopic approach in surgical endodontics with the applicability of retro mirrors and resected apical root segment atraumatically with more moderate resection angle. He concluded that the microsurgical approach leads to less trauma and faster healing.[31]

Conclusion

Some areas in the mouth may be difficult to access using the microscope; in such areas, loupes may be preferred. With the advent of newer systems such as varioscope, procedure scopes, these limitations may further be overcome. Above all the microscope can be a valuable patient education, practice enhancement, and self-appraisal tool, for improving the overall quality of work in day-to-day practice. The goal of magnification is to achieve the highest possible precision, better treatment, and prognosis. The use of magnification has enabled the endodontists to enhance their ability toward better diagnosis and treatment, to identify microfractures, to identify accessory canals, locate canal orifices, and identify anatomic variations in teeth and supporting structures. In the foreseeable future, the use of magnification is likely to become the standard of practice, particularly within the discipline of endodontics.

References

1. Dingra A, Nagar N. Recent advances in endodontic visualization: a review. J Dent Med Sci 2014;13(1):15–20.
2. Tibbetts LS, Shanelec D. Periodontal microsurgery. Dent Clin North Am 1998;42:339‑59.
3. Daniel RK. Microsurgery: Through the looking glass. N Engl J Med 1979;300:1251‑7.
4. Belcher JM. A perspective on periodontal microsurgery. Int J Periodontics Restorative Dent 2001;21:191‑6.
5. Barraquer JI. The history of the microscope in ocular surgery. J Microsurg 1980;1:288‑99
6. 6.Mallikarjun SA, Devi PR, Naik AR, Tiwari S. Magnification in dental practice: How useful is it?. Journal of Health Research and Reviews. 2015 May 1;2(2):39
7. Das UK, Das S. Dental operating microscope in endodontics – a review.IOSR J Dent Med Sci 2013;15(6):01–08.
8. Friedman M, Mora AF, Schmidt R. Microscope‑assisted precision dentistry. Compend Contin Educ Dent 1999;20:723‑8. Lang NP, Lindhe J. Periodontal plastic microsurgery. In: Clinical Periodontology and Implant Dentistry. 6th ed., Vol. 2. Oxford, UK:Wiley‑Blackwell; 2015. p. 1029‑44.
9. 9.Leonard S, Tibbetts LS, Shanelec DA. Principles and practice of periodontal surgery. Int J Microdent 2009;1:13-24.
10. 10.Wynne L. The selection and use of loupes in dentistry. Dent Nurs. 2014;10(7):390-22.
11. 11.Pradeep S, Vinoddhine. R. The Role of Magnification in Endodontics. Annals and Essences of Dentistry. 2014; 6(2): 38-43.
12. Singla MG, Girdhar D, Tanwar U. Magnification in endodontics: a review. Indian J Conserv Endod 2018;3(1):1–5. DOI: 10.18231/2456-8953.2018.0001.
13. 13.Mines P, Loushine RJ, West LA, Liewehr FR, Zadinsky JR. Use of the microscope in endodontics: a report based on a questionnaire. J Endod 1999;25:755–758.
14. Monea M, Hantoiu T, Stoica A, Sita D, Sitaru A. The impact of operating microscope on the outcome of endodontic treatment performed by

postgraduate students. Eur Sci J 2015;305 311.
15. Pecora G, Andreana S. Use of dental operation microscope in endodontic surgery. Oral Surg Oral Med Oral Pathol 1993;75:751–758.
16. Khayat BG. The use of magnification in endodontic therapy: the operating microscope. Pract Periodont Aesthet Dent 1998;10(1):137–144.
17. Singla MG, Girdhar D, Tanwar U. Magnification in endodontics: a review. Indian J Conserv Endod 2018;3(1):1–5. DOI: 10.18231/2456-8953.2018.0001.
18. Das UK, Das S. Dental operating microscope in endodontics – a review. IOSR J Dent Med Sci 2013;15(6):01–08.
19. 19 Bahcall JK, Barss JT. Endodontic therapy using orascopic visualization. Dent Today 2003;22(11):95-8.
20. 20 Bertrand G. The Use of magnification in endodontic procedure: The operating microscope.
21. 21.Anil Dhingra. Recent Advances in Endodontic Visualization: A Review
22. Von Arx T, Walker WA.2000. Microsurgical instruments for root-end cavity preparartion following apicoectomy: A literature review. Endod Dent Traumatol.,16:47-62.
23. Clauder T. 2007. The Dental Microscope: An Indispensable Tool in Endodontic Practice. The Microscope in Dentistry, USA, Philadephia, published by Carl Zeiss Meditec AG 1-4.
24. Rashed B, Iino Y, Ebihara A, Okiji T. Evaluation of Crack Formation and Propagation with Ultrasonic Root-End Preparation and Obturation Using a Digital Microscope and Optical Coherence Tomography. Scanning. 2019 Dec 30;2019.
25. Das UK, Das S. 2013. Dental Operating microscope in Endodontics-A review.J Dent Med Sci., 5(6):1-8.
26. Yoshioka T, Kobayashi C, Suda H. Detection rate of root canal orifices with a microscope. Journal of endodontics. 2002 Jun 1;28(6):452-3.
27. Ling JQ, Wei X, Gao Y. [Evaluation of the use of dental operating microscope and ultrasonic instruments in the management of blocked canals]. Zhonghua Kou Qiang Yi Xue Za Zhi. 2003 Sep;38(5):324-6. Chinese. PMID: 14680574.
28. Wu D, Shi W, Wu J, Wu Y, Liu W, Zhu Q. The clinical treatment of complicated root canal therapy with the aid of a dental operating microscope. Int Dent J. 2011 Oct;61(5):261-6. doi: 10.1111/j.1875-595X.2011.00070.x. PMID: 21995374.
29. Mines P, Loushine RJ, West LA. Liewehr FR, Zadinsky JR.1999. Use of the microscope in endodontics: A report based on a questionnaire. J Endod.,25(11):755-8.
30. Nunes E, Silveira FF, Soares JA, Duarte M, Soares S. 2012. Treatment of perforating internal root resorption with MTA: a case report. J Oral Sci., 54(1):127-31.
31. Paliwal A, Loomba K, Gaur TK, Jain A, Bains R, Vats A, Singh A,Sharma R, Majumdar DSP. 2011. Dental operating microscope (DOM): An adjunct in locating the mesiolingual (MB2) canal orifice in maxillary first molars. Asian J Oral Health Allied Sci., 1(3):174-9.