Magnification in Endodontics: A review

Meenu G. Singla[1,*], Divyam Girdhar[2], Usha Tanwar[3]

[1]Professor, [2]Senior Lecturer, [3]MDS Student, Dept. of Conservative Dentistry and Endodontics, Sudha Rustagi College of Dental Sciences and Research, Fariadabad, Pandit Bhagwat Dayal Sharma University, Rohtak, Haryana, India

***Corresponding Author:**
Email: meenu_sanjeevsingla@hotmail.com

Abstract
Traditional endodontics has been based on feel not sight. Since the endodontic surgical field is measured in millimeters, endodontic therapy has always been very dependent from the tactile sensation of the operator and its anatomic knowledge. The use of magnification in dentistry appears to be of increasing interest. With the recent advances of magnification devices with increased magnification and illumination there is improved technical accuracy and performance. Now the use of such magnification systems is a very popular practice in dentistry as well. By providing both intense focused light as well as a high degree of magnification, the endoscope, orascope, dental loupes and operating microscope has become an important part of the armamentarium for many endodontics. The aim of this review is to discuss the role of magnifying aids with its added advantages in endodontic.

Keywords: Magnification, Dental Loupes, Operating Microscope, Orascope, Endosocope.

Introduction
In clinical dentistry, the human skill and manual dexterity have great significance.[1] Visualizing the oral cavity has always been a challenging task for the dentists.[2] Earlier radiographs were the only way to see inside a root canal, and tactile sensation was used to perform endodontic procedures.[3] Syngcuk Kim stated that "You can only treat what you can see". [4] Undoubtedly, the clinician can better evaluate and treat something, if he or she sees it more clearly and in magnified form.[5] Size of the image can be enhanced by getting closer to the objects or by magnification.[6] Currently, to improve the quality of treatment, the endodontists have been trying to develop new technologies to achieve success.[7] Clinical procedure may be carried out successfully with the use of magnification that ensures precision and, hence, increases the quality of work.[6]

Presently, Loupes, Dental Operating Microscope, Orascope, Modular Endoscope system (microendoscope), Miniature endoscope systems are the magnification devices used in dentistry.[8]

History
Surgical loupes date back to the 1870s; however, they had been developed into a binocular loupe that could be attached to spectacles by the early 1900's.[9] In 1978 Dr. Apotheker and Dr. Jako introduced the concept of extreme magnification, in the form of an operating microscope, into dentistry. In 1999, a DOM was introduced by Gary Carr, that had Galilean optics and that was ergonomically configured for dentistry, with several benefits that permitted easy use of the scope for nearly all endodontic and restorative procedures.[4] In 1979, the use of endoscope in endodontics, which was made up of glass rod, was first reported in literature.[2] Use of Endoscopy in periapical surgery was described by Bahcall et al in 1999.[10]
Bahcall and Barss first reported the use of orascopic visualization made up of fiber optic in 1999.[2] To try and quantify the growth of magnification users, the term "Magnification Continuum" was coined in 2001.[11]

Dental Loupes
Loupes are not a new invention.[9] Magnifying loupes were innovated to address the problem of proximity, decreased depth of field, and eyestrain occasioned by moving closer to the subject.[2] 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[2]
A. According to their different optical construction:
Single Lens Loupe: It comprises of simple magnifying lens, which is a diopter and flat plane.[12] 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.[13]
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.[2] However, they cannot be practically used in dentistry due to size and weight

limitations.[1]

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.[2] The Galilean 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.[13]

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).[1]

Keplerian loupes: Keplerian also known as Prism loupes are the most optically advanced type of loupe magnification of present era.[14] They are called rooftop or Schmidt prisms as a prism is fixed at the top of it.[1] They provide magnifications up to 6x by using refractive prisms and are actually telescopes with complicated light paths,.[2]

Advantages and disadvantages: When compared to any other loupes. Prism loupes provide broader fields of view, wider depths of field and longer working distance.[12] However, they are heavier and more costly due to increased number of lenses.

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.[9]

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.[9]

Advantages of Loupes[12]:

i. It does not acquire much space, as it is small in size.
ii. No formal training is required as it can be easily operated.
iii. Surgeon's position is not restricted.
iv. Neither are they expensive as a microscope is nor do they need higher maintenance.

Disadvantages of Loupes[12]:

i. It does not provide depth perceptions due to lack of Stereoscopic view.
ii. With loupes, magnification beyond 5x is uncomfortable on nose or head due to their large size and increased weight. For higher magnification microscope should be considered.
iii. Head movement makes image unstable.
iv. Illumination is less in comparison to microscope.
v. The operating field must be covered by clinician's eyes: however, eyestrain, fatigue and changes in vision can be experienced if poorly fixed loupes are used for longer time.
vi. Accessories such as beam splitter, video camera, T.V camera or movie camera cannot be attached to a loupe to capture the magnified field.

Ergonomic criteria for loupe selection[2]

Considering ergonomic guidelines is imperative when selecting loupes, since poorly designed or poorly adjusted loupes can cause or worsen pain.

The 3 most significant ergonomic factors to consider when purchasing loupes are:

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

Dental Operating Microscope

The emergence of Endodontic operating microscope is the most important development that took place in the field of endodontic. The microscope not only provides better magnification from 3x upto 30x but also better illumination. The microscope through its enhanced vision has greatly contributed to improved surgical as well as conventional endodontic treatment.[15]

The introduction of the microscope includes numerous ergonomic changes. Possible reduction in consequent stress for the operator can be ensured by maintaining the traditional working positions previously used without the microscope by the clinicians. The range of working positions is usually from the 9 o'clock to the 12 o'clock position.[5]

The operating microscope consists of three basic components[2]

1. **The supporting structure**: The supporting structure should be mounted on the floor, ceiling or wall to ensure stability of microscope. Decrease in the distance between the fixation point and the body of the microscope will increase the stability. The floor mount is preferable in clinical settings with high ceiling or distant walls.[2]
2. **The body of microscope**: It is the most crucial element and consists of eyepieces, binoculars, magnification change factor, and the objective lens.[2]
   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.[15]
   b. **Binocular**: They are available with straight, inclined or inclinable tubes[2] with provision to hold the eyepieces.[15]
   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.[3]
   d. **Objective lens**: It is the final optical element, and its focal length determines the working distance between the microscope and the surgical field. The focal length ranges from 100 mm to 400 mm. A 200 mm focal length permits approximately 20 cm of working distance, which is generally appropriate for utilization in endodontics. A layer of anti-reflective coating ensures absorption of only a minimum amount of light in order maintain the illumination of the operative field.[2]
3. **The Light Source:** It is one of the key features and responsible for working in operative fields that are small and deep like the root canal.[2] Its source is 100watt Xenon halogen bulb, whose intensity is controlled by rheostat and cooled by a fan. Illumination and line of sight share the same axis, which means that light is focused between the eyepieces so that no shadows will be visible. Galilean optics makes it possible.[3]

Advantages of Dental Operating Microscope[2]

i. Increased visualization, and hence improved the quality and precision of treatment.
ii. Enhanced ergonomics.
iii. Ease of proper digital documentation and;
iv. It contains integrated video, which makes the communication skill better.

Disadvantages[16]

i. It's expensive.
ii. It is difficult to fit in a small operation because of its size.
iii. It takes the operator some time to get used to the equipment.
iv. Need for expertise by auxiliary staff and adaptation is quite difficult.
v. It provide narrower field of vision.

Ergonomics[17]

The knowledge of the basic ergonomic motion is necessary for understanding of efficient workflow of microscope.

Adjustment of the operator seating position is done so that the hips are 90° to the floor, the knees are 90° to the hips and the forearms are 90° to the upper arms. The operator should place his forearms comfortably on the armrest of the operator's chair and his or her feet should be placed flat on the floor. Operator's back should be in neutral and erect position, being perpendicular to the floor. The lumbar support of the chair should support the natural curvature of the back.

In order to get definitive patient position, it is essential to make little movement with back of dental chair. Under microscope, all non surgical endodontic work is done under indirect vision through the mirror. Therefore, the position of the patient depends on angle that the light of the microscope has to make in order illuminate the root canal. Patient should be positioned so that light beam is perpendicular to the floor and the mirror is 45° to light. Therefore, while working in a maxillary root canal patient should be horizontal & parallel to the floor and while working in mandibular root canal, patient should be in "Trendelenburg" position, which means with the head slightly lowered to the pelvis.

During surgical endodontics, the surgeon should be at 11–12 O'clock position.[18] Patient's head should be tilted up or down, for straight-line access through the microscope while working in anterior region. When working in the posterior region, the patient is instructed to lie on his or her side as if sleeping. This allows the operator to look directly into the field. A trick while working on mandibular molars for better vision is to have the patient closing in a slightly class III occlusion, bringing the buccal surface out. Perhaps the most difficult root to visualize surgically is the mesiolingual root of mandibular molars. Using this technique, the operator can often establish direct vision of this root.[19]

Orascope

An orascope is a fiberoptic endoscope, which is made up of plastics, and therefore, they are small, lightweight, and flexible. It has a 0.8mm tip diameter, 0º lens, and a working portion that is 15mm in length and it is used for intracanal visualization. The image quality depends on the number of fibres and the size of the lens used in an orascope. The orascope has 10,000 parallel visual fibres with diameter 3.7 to 5µ. The visual fibres are surrounded by a ring of much larger light

transmitting fibres that aid in illumination of the treatment field. Clinicians appreciate that orascopic technology has a non-fixed field of focus, which allows visualization of the treatment field at various angles and distances without losing focus and depth of field.

The canal must be prepared to a size No. 90 file in the coronal 15 mm prior to the placement of the 0.8-mm fiber-optic scope. This allows the full 15 mm of the orascope to penetrate within the canal otherwise a wedging of the probe may occur, damaging some of the fibers within the scope.

Although the orascope can be used when sodium hypochlorite is present in the canal but this solution has a high light refractory index which causes greater amounts of light to be reflected, thus making it difficult to see the details of the canal.[20] Therefore, the canal must be dried prior to usage of the 0.8-mm scope.

Endoscope

The term endoscopy is of Greek origin and is literally translated as endon (within) and skopion (to see), thus meaning, "to see within". With the advent of dental endoscope, the field of endoscopy has expanded further. The traditional endoscope used in medical procedures consists of rigid glass rods. It can be used in apical surgery as well as nonsurgical endodontics. The recommendation for surgical endodontic visualization is a 2.7mm lens diameter, a 70º angulation, and a 3 cm long rod-lens and for a non-surgical visualization through an occlussal access opening, a 4mm lens diameter, a 30º angulation, a 4 cm long rod-lens are recommended.[12] Prior to the use of an endoscope, a pair of 2-2.5 X loupes should be used for visualization. The scope cannot provide a discernible image when placed in blood, thus hemostasis of the surgical field must be obtained before the endoscope is used. To stabilize the endoscope, it should be placed on bone around the crypt.[20] Endoscope can be rigid, flexible and semiflexible. The rigid endoscope is of less value, while the flexible and semi-flexible endoscopes can be very valuable addition to armamentarium. The semi-rigid endoscope incorparates the advantages of flexible and rigid mini-endoscopes: it has a clear view, a small diameter, stiffness and good "pushability". Hence it is considered the best instrument available.[21]

Miniature endoscope for root canal treatment includes- A handpiece basically consists of three segments: A semi-flexible examination probe, which is inserted into the root canal, including an ergonomic handle, flexible optical fiber connections for light transmission (toward distal) and image transmission (toward proximal) and rigid eyepiece with a cold light source connection and coupler for a high-quality CCD camera. In endodontic endoscopy, the best method is suction formation with low-pressure vacuum via the channel and intermittent irrigation using isotonic saline. Parallel working is another option of working with the endoscope is. In this option the endoscope in the channel together with the instrument.[21]

Modular Endoscope System is based on modern technology of microendoscope. It is used in small channel organs like salivary gland ductal system and tear channel. It is designed to enable the practitioner to work inside the root canal with magnification and instrument access.[12] The endoscope has a nitinol coating which makes it flexible.[8] This system includes three parts: endoscopic compact system, optical part that includes ocular part and the endoscope, and handpiece with a disposable part.[12]

Uses of Magnification in Endodontics

Implications of endodontic magnification devices can be categorized into following areas:

1. **Diagnosis:** By nature of the specialty, an endodontist should be a master diagnostician. Any equipment or methodology that assists in diagnosis should be appreciated. The use of magnification in cases such as cracked or vertically fractured teeth has a tremendous help in visualizing how far these fracture lines extend and where they end.[15]
2. **Nonsurgical Endodontics:** magnification helps in conventional root canal treatment like preparing and finishing the access cavity; shaping the root canal precisely; filling the system completely in three dimension. Another uses such as detection of root canal orifice, location of missed canal, removal of fractured post and instrument, perforation repair.[3]

   Magnification devices have more chances to detect MB2 canals in comparison to naked eye.[22] However, Operating Microscope has better outcome than loupes in detecting MB2 canals.[23] A combination of Operating Microscope & ultrasonics is a effective method for removing fracture instrument than conventional method.[24]
3. **Role of magnification in surgical endodontics:** The microscope has contributed to improved surgical treatment through enhanced vision. Carr, Kim, Pecoro and Rubinstein promoted the use of microscope for surgical procedures in late 1980's and early 1990's. The introduction of the operating microscope and ultrasonic instruments has taken endodontic surgery to another level of sophistication i.e., the microsurgical approach. Magnification, illumination and instruments constitute a microsurgical triad. Apical surgery can now be performed with accuracy and predictability, eliminating the guess factor inherent in a conventional endodontic surgery.[15] Using a microscope to perform endodontic surgery, the higher magnification and illumination allow the operator to more easily distinguish between cutting bone (whiter appearance) and cutting the root tip (more yellow), aid in complete removal of granulomatous material, no or less than 10° bevel

is given through the microscope.[19] However, according to a study there was no statistically significant difference found in treatment outcome of endodontic microsurgery using two different magnification devices (magnifying loupes & microscope).[25] Another study reported endoscope provides excellent visualization of the surgical field during root end management and can be an aid for endodontic surgical procedures.[26]

4. **Documentation:** Another aspect of endodontic practice that is enhanced by the magnification is documentation.[15] Digital documentation capabilities enable the clinician to efficiently capture and share with patients what is seen during an examination pre-operatively, intra-operatively and post-operatively and stored in patients chart. This is especially useful when unforeseen problems are encountered. The usage of documentation for medico-legal, insurance, patient communication, and lecturing purposes, as well as for communication with staff or colleagues, is also impressive.[4]
5. **Best Cosmetic Outcome and tissue conservation** by use of the thinnest suture threads and flap designs like the papilla base incision, which is otherwise never possible under the naked eye.[3]
6. **Ergonomics** comes from the Greek words- ergon, which means work, and nomos, which means correctness which means working correctly.[27] Magnification increases the image in order to see small object accurately. Magnification reduces the eye fatigue and posture problems as well.

Summary and Conclusion

Currently, in order to progress in the quality of treatment, the endodontist has been seeking support for new technologies to achieve success.[7] However, choosing and purchasing a magnifying device involves a great number of issues, including the adequacy of one's present vision, the type of practice conducted, the demands one places on the quality of his or her dentistry, and the amount of time and expense one wishes to devote becoming competent in using magnification.[15]

References

1. Mallikarjun SA, Devi PR, Naik AR, Tiwari S. Magnification in dental practice: How useful is it?. J Health Res Rev 2015;2(2):39-44.
2. Pradeep S, Vinoddhine. R. The Role of Magnification in Endodontics. Annals and Essences of Dentistry. 2014; 6(2): 38-43.
3. Kumar R., Khambete N., Surgical operating microscopes in Endodontics: Enlarged vision and possibility. Int J of Stomatological Research; 2013;2(1):1-15.Surgical Operating Microscopes in Endodontics: Enlarged Vision and Possibility. 2013;2(1):11-5.
4. Das UK, Das S. Dental Operating Microscope in Endodontics-A Review. J Dent Med Sci.2013;5(6):1-8.
5. Sharma N, Sharma A, Mantri V. MAGNIFICATION IN ENDODONTICS. NJDSR.2014; 2(1):90-3.
6. Mohan R, Gundappa M. Magnification Tools: Surgical Operating Microscope and Magnifying Loupe in Dental Practice. IJERTV. 2013;2(8):14-22.
7. Lins CC, Silva EM, De Lima GA, Menezes SE, Travassos RM. Operating microscope in endodontics: A systematic review. Open J Stomatol 2013;3:1-5.
8. Bansal A, Chaudhary D, Kukreja N, Gupta NK, Kukreja U, Bansal J, Sibal N."Seeing Is Believing" - Endoscopy In The Clinical Practice Of Dentistry: A Review Of Literature. Int J Dent Sci.2012;4(4):97-101.
9. Wynne L. The selection and use of loupes in dentistry. Dent Nurs. 2014;10(7):390-22.
10. Maestre-Ferrín L, Peñarrocha-Diago M, Peñarrocha-Oltra D. Magnification in apical surgery using the endoscope: a review. J Clin Exp Dent. 2011;3(5):462-4.
11. Glenn A. Van As. Incorporating Magnification into your Dental Practice.
12. Dhingra A, Nagar N. Recent Advances in Endodontic Visualization: A Review. JDMS. 2014;13(1):15-20.
13. Mamoun J, Wilkinson ME. Technical Aspects and Clinical Usage of Keplerian and Galilean Binocular Surgical Loupe Telescopes used in Dentistry or Medicine. 2013;(4):142-9.
14. James T, Gilmour ASM. Magnifying loupes in modern dental practice: An update. Dent. Update. 2010;37(9):633-36.
15. Neha. An insight into magnification. Guident July 2012:49-53.
16. Kamath D, Paul J, Joseph A, Varghese J. Magnification in Endodontics Dental Loupes Vs Microscope. J Odontol Res.2015;3(1)31-4.
17. Carr GB, Murgel CA. The use of the operating microscope in endodontics. Dent Clin North Am 2010;54:191–214.
18. Ananad S, Soujanya E, Raju A, Swathi A. Endodontic microsurgery: An overview. Dent Med Res 2015;3:31-7.
19. Kratchman S. Endodontic Microsurgery. Compendium June 2007;28(6):324-31.
20. Bahcall JK. Visualization in endodontics. Eur J Gen Dent 2013;2:96-101.
21. Moshonov J and Nahlieli O. Endoscopy in endodontics. Alpha omegan 2011;104:26-34.
22. Hasan M, Khan FR. Diagnosis of Second Mesiobuccal Canal in Maxillary First Molars among Patients Visiting a Tertiary Care Hospital. Int J Biomed Sci2015;11(2):107-8.
23. Schwarze T, Baethge C, Stecher T, Geurtsen W. Identification of second canals in the mesiobuccal root of maxillary first and second molars using magnifying loupes or an operating microscope. Aust Endod J. 2002;28(2):57-60.
24. Alaçam T, Tinaz AC, Genç O, Kayaoglu G.Second mesiobuccal canal detection in maxillary first molarsusing microscopy and ultrasonics. Aust Endod J 2007:1-4.
25. Taschieri S, Weinstein T, Tsesis I, Bortolin M, Del Fabbro M (2013) Magnifying loupes versus surgical microscope in endodontic surgery: a four-year retrospective study. Aust Endod J 39:78–80.
26. Taschieri S, Del Fabbro M. Endoscopic endodontic microsurgery: 2-year evaluation of healing and functionality. Braz Oral Res 2009;23(1):23-30.
27. Vahedi B, Goczewski M, Oscar Freiherr von Stetten. Carl Zeiss. Microscopic dentistry.APracticalGuide.53-69.https://www.zeiss.com/content/dam/Meditec/downloads/pdf/dental book/microsurgery_book.pdf