Review Article

Magnification-Enhanced Contemporary Endodontics

Manish Sundesha, Anita Choudhary, Monika Tomar, Vaishak Augustine

Department of Conseravtive Dentistry and Endodontics, Vyas Dental College and Hospital, Jodhpur, Rajasthan, India

ABSTRACT

Endodontic treatment is based upon feel not the sight; over the past few decades, technological advancements in endodontics have taken quantum leaps from conventional hand files to the rotary system and from the direct vision to the magnification. The clarity and details are achieved by magnification devices such as orascope, dental loupes, and dental operating microscope. In the recent years of advancements in magnification devices with increased magnification, illumination, unobstructed vision, smaller instruments, minimal trauma, and ergonomic benefits which helps in more technical accuracy and performance. Even though the use of microscope initially started in ophthalmology, its benefits in endodontic therapy which can be best performed under magnifications up to ×10–20 remains unparalleled. These benefits also extend to all the aspects of including conservative dentistry, non-surgical endodontic, surgical endodontic procedure. Barring the disadvantages of steep learning curve, cost, and maneuverability of the equipment, magnifications are definitely becoming an important aspect of the modern days dentistry, due to their numerous other benefits. The aim of this review for the magnification aids in endodontics was to describe in detail various magnifying devices, their use and the advantages and disadvantages in clinical, surgical, and conventional endodontic therapy with the recent innovation and technological advancement in magnifying.

Key words: Endodontic, Magnification, Microscope, Dental loupes, Orascope, Endoscope

INTRODUCTION

Endodontist feels that they can do mostly of work blind folded easily because there is "nothing to see." There is a biggest concern in doing endodontic therapy with right tools to achieve better success rate.[1] In the early days, radiographs were the only way to see inside a canal of the tooth, and tactile sensation was used to perform the endodontic treatment.[2] Visualization of surgical and conventional endodontic treatment has historically been limited to the two dimensions of a dental radiograph that is representative of a three dimensional biological system and finding the track of entry and lives from pulp space and hermetic seal after debridement is the basic in the endodontics.[3]

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A good illumination and better magnification are required for more advanced endodontics.[3] Magnification is the procedure to enhance the visual object only in appearance and not in physical size. This enlargement is quantified by a count number also called "magnification." Visualizing in the oral cavity has always posed a complex in dentistry.[1] Magnification offers a higher number of benefits such as: Improved diagnosis especially in case of cracked teeth, better visualization of pulp chamber, root canal orifices and calcifications present, identification of complex root canal systems, effective cleaning and shaping and its visualization subsequently improved control over obturation of root canal system, superior management of open apex cases and those with internal resorption; predictable sealing of perforations and identification of missed canals, fractured instrument in the restorative dentistry as well as in endodontics.[4]

Many magnification devices have been introduced as chain equipment between the naked eyes and the microscope. In fact, instruments such as an endoscope, magnifying glass, and intraoral camera, have largely been superseded by contemporary devices that seem to be more practical

Address for Correspondence:
Dr. Manish Sundesha, Vyas Dental College and Hospital, Jodhpur - 342 005, Rajasthan, India.
E-mail: manishsundesha884@gmail.com

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and convenient for application, such as loupes and dental operating microscope (DOM).[5]

HISTORY

In the year 1876, Dr. Edwin Saemisch, a German ophthalmologist, presented simple binocular loupes to surgery. Dr. Geza Jako, an otolaryngologist, used the surgical operating microscope (SMO) in 1962 during oral surgical process. Dr. Robert Baumann, an otolaryngologist and practicing dentist who described the use of the otologic microscope in dentistry field in 1977. The development of a microscope specifically designed for dentistry was begun by Dr. Harvey Apotheker; a dentist from Massachusetts and Dr Jako in 1978. In 1980, Dr Apotheker coined the term "micro dentistry." The "Dentiscope" was manufactured by Chayes - Virginia Inc., USA that is marketed by the Johnson and Johnson Company.[6] In 1979, the use of endoscope became popular in endodontics, which was made up of glass rod. The Use of Endoscopy in periapical surgery was defined by Bahcall *et al*. in 1999. Bahcall and Barss first reported the use of orascope visualization made up of fibre optic in 1999.[2] Dr. Gabriele Pecora gave the first presentation on the use of the DOM in surgical endodontics at the 1990 annual session of the American Association of Endodontist in Las Vegas, Nevada.[7]

NEED FOR ENHANCED VISION IN DENTISTRY

Any device which enhances or improves a clinician's resolving power is exceptionally beneficial for producing accuracy in the dentistry. Restorative dentist and endodontist routinely perform procedures such as crown margins, incisions, root canal location, caries removal, furcation and perforation repair, post placement or removal that requiring resolution well beyond the 0.2-mm limit of human sight.[1]

OPTICAL PRINCIPLE

Stereopsis or three-dimensional perceptions is critical to achieving precision dentistry, since all the clinicians must "construct" three-dimensional structures in a patient's mouth, Dentists appreciate that human mouth is a relatively small space in which to operate, especially considering the size of the available instruments (burs, hand pieces, etc.) and the comparatively large size of the operator's hands.[8] Many attempts have been made to use the magnifying endoscopes used in the arthroscopic procedures but these devices require viewing on a two-dimensional monitor and the limitations of working in 2D space are too. Several factors are important for consideration in improving clinical visualization.

Many factors which influence the clear vision are: Stereopsis, Magnification, Depth of field, Eyestrain, Resolving power, Working distance, Ergonomics, Head and neck fatigue and cost.[9]

Without using any supplemental device by simply moving closer to the object, dentists can increase their resolving ability. This movement is accomplished in dentistry by raising the patient up in the dental chair by the operator bending down close to the patient. This method is limited, however, by the eye's ability to refocus at the diminished distance.[10]

Most of the people cannot refocus at distances closer than 10–12 cm. when eye-subject distance (i.e., focal length) decreases; the eyes must converge that creating eyestrain. One fact must also take into consideration that as one ages the ability to focus at closer distances is compromised due to the lens of the eye, loses flexibility with age. This phenomenon is known as presbyopia. The eye (lens) is not able to accommodate that produce clear images of near objects. The nearest point, at which the eye can focus accurately, exceeds ideal working distance.[8] As the focal distance decreases, the 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 an adequate solution for increasing a clinician's resolution. On the other hand, image size and resolving power can be increased using lenses for magnification, with no need for the position of the object or the operator to change.[8]

TERMINOLOGY

Microsurgery

This refers to a surgical medical procedure performed under magnification by a microscope.[11]

Magnification

Magnification is a phenomenon in which visually amplifying and availing an enlarged, exaggerated, intensified view of an object or an image or a model. The SMO like loupes offer various options of magnification within the same instrument. Such instruments have six steps of magnification (2.5×, 4.0×, 6.7×, 10×, 16×, and 24×) used by the dentists for microsurgery.[12]

Working Distance

Working distance is the distance between the plane of the eye of the operator and the surface subjected for the surgical treatment. To determine this working distance is done by the linear measurement of the distance between the objective front lens of the microscope and surgical site. An adequately longer working distance provides the operator to perform comfortably with the help of the magnified vision.[13]

Depth of Field (Working Range)

It is the range within the appropriate working distance, where the operator has the ability to maintain the visual accuracy.[14]

Declination Angle

Declination angle is the degree where the eyes of the operator are declined to view the area being treated. Declination angles range from 15° to 44°.[14]

Field of View

This is many times known as "width of field." That is type of the width and height of the area the operator sees while using the magnification devices and linear size or angular extent of an object when viewed through the telescopic system.[12,13]

Viewing Angle

Viewing angle is the position of the binocular optics which angled in such a way that it enables comfortable working position for the operator. When viewing angle is shallow, then chances are greater to tilt the neck to view the object.[13]

Convergence Angle

It is the pivotal angles aligning the two oculars, such that they are pointing at the identical distance and angle varies with inter pupillary distance (IPD) and also defines the position of extra ocular muscles that may result in tension of the internal and external rectus muscles, which may be an important source of eye fatigue.

ENDODONTIC VISUALIZATION SYSTEM

Endodontic visualization systems devices are as follows:-
1. Magnifying glasses
2. Dental loups/telescope
3. Microscope
4. Endoscope
5. Orascope

Magnifying glasses

The magnifying glass is one of the oldest devices which are used to improve sight. Modern magnifying glasses are double-convex lens mounted in a frame with a handle and they make the objects appear larger. While viewing objects the light rays are bent toward the center of the lens that making the object look larger than it is to the eye. Each magnifying glass has a focal length, which is the distance from the optical center of the lens to the point where the light rays converge.[15] This happen due to the distance between the lens and the object is shorter than the focal length of the lens.[16] A typical type of magnifying glass might have a focal length of 25 cm that corresponding to an optical power of 4 diopters. Such magnifier is available as a "2X" magnifier. There are many different sizes are available from the small round compact pocket magnifying glasses to the large rectangular full-page magnifiers. Many have built-in lighting systems to allow the user to see objects better.[15]

Magnifying glasses typically have low magnifying power: 2X – 6X, with the lower-power types being much more common. At higher magnifications, the image quality of a simple magnifying glass becomes poor due to optical aberrations in particularly spherical aberration. When more magnification or a better image is required in that time other types of hand magnifier are typically used. A Coddington magnifier can be used which provides higher magnification with improved image quality.

Dental loupes

Dental loupes were among the earliest refined tools to provide an enlarged image of working site procedure. Currently used loupes are more advanced, based on Galilean optics which are presented in different configuration like with sports frame, with titanium frame, headband, and through the lens type (TTL).[17]

The loupes are mainly classified in to four types: [16]
- Based on the number of lens
- Single lens
- Multiple lenses
- Galilean optic loupes
- Prism loupes
- Based on the magnification system
- A diopter, flat plane, single lens loupes
- Surgical telescope (Galilean optical system)
- Surgical telescope (Keplerian optical system)
- Based on the design of loupes
- Through the lens loupes
- Flip-up loupes.

Single lens

Simple loupes consist of a pair of single, positive, side by side meniscus lenses.[12] Single lenses have a fixed focal length and working distance.[18] Each lens has two refracting surfaces and the first refraction occurs when light enters the lens while the other refraction happens when the light leaves. The magnification of simple loupes can be increased only by enhancing the lens diameter or increasing the lens thickness.[8] The advantages to these types of simple loupes are low cost and lightweight since they are made out of plastic. The disadvantage of single lens loupes is the poor image resolution as compared to multi lens glass optics (telescopic loupes and microscopes).

Galilean optic loupes

It is also known as multi-lens loupe.[2] These loupes are cheap and simple to operate when compared to other type of the compound loupes. Loupes consist of only 2 or 3 lenses which make them light in weight and also inexpensive.[12] An enlarged viewing image is produced with a multiple lens system with the working distance between 11 and 20 inches. 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.[2] The Galilean loupes provide the magnification of 2.5X that imparts a good compromise between optical performance, weight, and cost.

Prism loupes

Prism loupes are the most optically advanced type of loupe magnification available now a days.[6] As their name suggests, these loupes consist prisms which are used to refract light rays. These loups have prism fixed at the top, that, they are called as rooftop or Schmidt prisms.[12] In Prismatic type of loupes, the passage of light is lengthened through a series of internal reflections through a Schmidt prism and allowing the barrel of the loupe to be shortened sufficiently for spectacle or headband mounting.[14]

Diopter (D), flat plane, single lens loupes

It consists of simple magnifying lens, which is a D and flat plane.[2] The D system relies on a simple magnifying lens,[1] which is focusing distance between eye and the object.[19] The degree of magnification is usually measured in D.[1] One D means that a ray of light that would be focused at infinity would now be focused at 1 m (100 cm or 40 in). A lens with 2 D designations 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 (i.e., 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).[1]

Surgical telescope with Galilean and Keplerian optical system

The type of glass multi lens configuration is known as a Galilean optical system. It provides a higher level of magnification, improved depth of field and working distance along with high optical resolution as compared to single plastic lens optics. Telescopic loupes use the Galilean optics.[18] The Galilean system provides a magnification range from 2 xs up to 4.5 xs and is a small, light and very compact system.[8]

Keplerian optical system is based upon the Keplerian astronomical telescope which uses five lenses and two prisms. The advantages to this optical system are superior optical clarity and flatter view from edge to edge.[18] The prism loupes (Keplerian system) use refractive prisms and they are actually telescopes with complicated light paths, which provide magnifications up to 6X.[8]

Operating microscope

Use and advantage of the operating microscope for conventional endodontics was first reported by Baumann.[3] In 1991, Gary Carr introduced an operating microscope with Galilean optics principles and ergonomically configured for dentistry with several advantages that allowed for easy use of the scope for nearly all endodontic and restorative procedures.[8]

The operating microscope consists of three basic components: [16]

1. The supporting structure
2. The body of microscope
3. The light source.

THE SUPPORTING STRUCTURE

It is essential that the microscope should be stable while in operation, yet remains maneuverable 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. The floor mount is more preferable in clinical settings with high ceiling or distal walls.[8] Even though it is stated that it can be easily moved from one operatory room to another, in point of fact, it is very unsuitable to do this and is a very ineffective way to use a microscope.

THE BODY OF MICROSCOPE

- Eyepieces: Magnifying the image is the most important function of the operating microscope. The power of eyepiece determines the magnification.[2] Eyepieces are generally available in various powers, ranging from 6.3X to 20X; the two most commonly used are 10X and 12.5X.[20] Most of the endodontic and restorative procedures can be carried out fewer than 10X magnification but certain endodontic procedure such as instrument retrieval or working on the apical foramen, may require magnification up to 15X-20X.[21]
- Binoculars: The binoculars hold the eyepieces.[3] It contains the eyepieces and allows the adjustment of the interpupillary distance.[20] It is available in different focal lengths.[3] They are aligned manually or with a small knob until the two divergent circles of light combine to affect a single focus.[8] With straight, inclined, or inclinable tubes, different binoculars are available.
- Magnification changer: It is placed within the head of the microscope and it is available in the range of 3, 5, or 6 step manual changer or a power-zoom changer.[8] They consist of lenses mounted on turret that is connected to a dial located on the side of microscope.[20] The magnification is adjusted by rotating the dial. A power zoom changer is a series of lenses that move back and forth on a focusing ring to give wide ranges of magnification factors.
- Objective lens: The objective lens is the final optical element, and its focal length determines the working

distance between the microscope and the surgical field.[8] A 200-mm objective lens is the preferred one as there is adequate room to place surgical instruments and still be close to the patient,[22] which is generally sufficient for use in the endodontic procedure.[8]

THE LIGHT SOURCE

Increased illumination of the operating field can be achieved using surgical headlights mounted on loupes, using a fiber-optic cable to transmit the light.[23] The light source is one of the most important features of an operating microscope and the light source is responsible for operating in operative fields that are small and deep during endodontic and restorative procedures.[8] Coaxial illumination is one of the best relevant advantages of DOM[24] which means that the light is focused between the eyes in such a manner that we can look into the operating field without seeing any presence of shadow.[25]

ENDOSCOPE

The use of endoscope in endodontics was first reported in 1979.[26] In 1996, other authors had recommended endoscope in surgical and conventional endodontic procedures.[27] The endoscope allows clinicians, greater magnification than can be achieved with the loupes or a microscope with the optical resolution comparable to the microscope and loupes. Even though 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 as compared to a microscope.[18]

ORASCOPE

Bahcall and Barss first reported the use of orascopic visualization in 1999. Orascopic endodontics is the use of orascopy for visualization in conventional or surgical endodontic treatment.[1] An orascope is a fiberoptic endoscope, which is made up of plastic, and therefore, they are small, lightweight, and flexible and like the rod lens endoscope that works in junction with a camera, light source, and monitor.[2,18] The number of fibers and size of the lens used are the determining factors of image quality.

USES IN ENDODONTIC THERAPY

Use in Restorative Dentistry

With the nature of the specialty, an endodontist should be an expert diagnostician. Any equipment or methodology that assists in diagnosis should be appreciated. The use of magnification by the endodontist in cases such as cracked or vertically fractured, marginal leakage, coronal preparation, evaluating the restoration under-surface, restoration delivery and polish, and bonded restoration tooth.[28]

Non-surgical Endodontics

Magnification helps in conventional root canal treatment such as preparing and finishing the access cavity; shaping the root canal precisely; and filling the system completely in three dimensions. Other uses such as detection of root canal orifice, location of missed canal, removal of fractured post and instrument, and perforation repair.[3]

Role of Magnification in Surgical Endodontics

Surgical endodontic procedures have been completely transformed by the magnification procedures.[29] The success of endodontic surgery is more often compromised by anatomic restrictions and root aberrations (i.e., the number and location of canal exits). The microscope has contributed to improved and clear 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, that is, the microsurgical approach. Magnification, illumination, and instruments constitute a microsurgical triad.[2] Every step of the surgical procedure benefits from enhanced magnification and illumination.[20] To improve the chances of clinically detecting multiple exits and isthmi and to parallel the retro preparation and root-end filling to the root axis, one must depend on intense illumination and an unobstructed magnified view.[29]

CONCLUSION

Endodontics has changed tremendously in the past two-three decades in relation to the use of magnification devices. Introducing the magnification in dentistry, especially in endodontics, has been a significant addition to the profession's armamentarium. However, choosing and purchasing a magnifying device involves a higher 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.

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