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Magnification In Endodontics

Dr. Saraswati Sachan, Dr. Isha Srivastava, Dr. Divya Pandey
Post Graduate Student, Department of Conservative Dentistry and Endodontics,Sardar Patel Post graduate institute of dental and medical sciences, Lucknow

Abstract: *Conventional Way Of Endodontic Treatment Is Based Upon Feel Not The Sight; However The Other Adjunct Like Radiograph And Electronic Apex Locator As Produced Surprising Success. But Still In Long Term There Is Significant Failure Rate. Magnification Increases The Ability Of Operator To Visualise Even The Smallest Detail For Proper Diagnosis And Treatment Of Dental Pathology. Despite Their High Cost, Integration Of Dental Operating Microscope Into An Endodontic Practice As Improve The Quality Of Treatment And Ergonomics.*

I. Introduction

Microscope is an instrument that focuses light or other radiation through one or more lenses to form a magnified image of a specimen which is too small for the naked eye.The science of investigating small objects using such an instrument is microscopy and in other word invisible to the eye unless aided by a microscope.(16)Microscope has been used in medical field to overcome the limits of human vision. Although clinicians have routinely strived to create bacterial-free seals .The resolving power of the unaided human eye is only0.2 mm. In other words, most people who view two points closer than 0.2 mm will see only one point. Simple calculations show that one cubic inch can contain millions of billions of viruses. Unfortunately, the calculations do not end there. For example, macromolecules (e.g., bacterial toxins, etc.) are measured in nanometres, or one billionth of a meter (2).Some of these bacterial toxins are so potent that even Nano grain quantities can cause serious complications and even death. Clearly, dentists are at a severe disadvantage in their attempts to replace natural tooth structure with artificial materials that do not leak, in view of the virtually invisible microbiologic threats to restoration integrity (14). The use of microscope was started 50 years back in otolaryngology , neurosurgery, urology, plastic, ENT, reconstructive surgery ,gynecology etc and most recently in clinical dentistry ,the dentist is now practicing a higher level of microscope Assisted Precision(MPA) Dentistry(16). The incorporation of the microscope in clinical endodontics has profound effects and has changed the field fundamentally.

History Of Operating Microscope:

The use of magnification to enhance visualization in dentistry dates back over a century. In 1876 Dr. Edwin saemisch, a German ophthalmologist introduced simple binocular loupes to surgery. Soon after dentist began experimenting with loupes to assist in the performance of precision dentistry & this continued to be the practice until the late 1970s.

In 1962 ,Dr Geca Jako ,an otolarygologist,used the SOM in oral surgical procedure.(13)Dr. Robert baumann, anotolaryngologist and practicing dentist ,described the use of otologic microscope in dentistry in 1977.He predicted that the SOM would find a place in the armamentarium of modern dentist as it did in otorhinolaryngology, neurosurgery ,vascular medicine, and gynecology.

In 1978, Dr. Harvey Apothekar, a dentist from Massachusetts & Dr. Jako brought the concept of extreme magnification in the form of an operating microscope, intodentistry (15). In 1980, Dr. Apothekar coined the term "Micro dentistry".

The dent scope was manufactured by Chayes- virginia Inc., USA & marketed by the Johnson & Johnson Company .The dentiscope had a single magnification of 8 and dual fiberoptics lights which were directed toward the surgical field. The unit could be mounted on a mobile stand or could be permanently mounted to a wall.

Dr. Richard Rubinstein and Dr. Garry Carr began using medical-grade microscope for apical surgery in1990.

In July 1982, the First International Congress in Microsurgical dentistry was held in Bordeaux, France. Dr. Apothekar continued to work and research on the operating microscope. In 1984, along with Dr. Howard seldomreported its use for apical surgery.

By 1995, there was considerable increase in the use of SOM. Microscope companies such as Zeiss, Global & JED MED offered microscopes with a variety of features that could accommodate virtually any practitioner & office environment. Improved lighting systems, variable adjustable binoculars & improved ergonomics created opportunities for visual acuity that were far superior to what was available just a decade earlier.

In 1997 Syngcuk Kim stated that endodontics has fundamentally changed in the last 5 years after the introduction of surgical microscope. He pointed out that apical resection technique is totally different than before and orthograde procedure that was once very difficult can be done with much certainty.

In 1999 ,Garry Carr ,introduced a DOM that had Galilean optics that was ergonomically configured for dentistry ,with several advantages that allowed for use of the scope for nearly all endodontic and restorative procedure.[4]

Principle of optics:

Since all clinicians must “construct” three-dimensional structures in a patient’s mouth, stereopsis, or threedimensional perceptions, is critical to achieving precision dentistry. Dentists appreciate that human mouth is a relatively small space in which to operate, especially considering the size of the available instruments (burs, handpieces, etc.) and the comparatively large size of the operator’s hands. Attempts have been made to use the magnifying endoscopes used in arthroscopic procedures but these devices require viewing on a two-dimensional monitor and the limitations of working in 2D space are too restrictive to be useful. Several elements are important for consideration in improving clinical visualization. Factor which influence the clear vision are:Stereopsis, Magnification ,Depth of field ,Eyestrain ,Resolving power, Working distance, Ergonomics ,Head and neck fatigue and cost.

Dentists can increase their resolving ability without using any supplemental device by simply moving closer to the object .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.

Most people cannot refocus at distances closer than 10- 12 cm. Furthermore, as the eye-subject distance (i.e., focal length) decreases, the eyes must converge, creating eyestrain. One must also take into consideration the fact that as one ages the ability to focus at closer distances is compromised. This phenomenon is called presbyopia and is due to the fact that the lens of the eye loses flexibility with age. The eye (lens) is unable to accommodate and produce clear images of near objects. The nearest point at which the eye can focus accurately, exceeds ideal working distance.[1]

As the focal distance decreases, depth of field decreases .Considering the problem of the uncomfortable proximity of the practitioner’s face to the patient, moving closer to the patient is not a satisfactory solution for increasing a clinician’s resolution. Alternatively, image size and resolving power can be increased by using lenses for magnification, with no need for the position of the object or the operator to change.

Other Means Of Magnification- Loupes:

Initially for magnifying the objects other means like loupes were used**.** Magnifying loupes were developed to addressthe problem of proximity, decreased depth of field, and eyestrain occasioned by moving closer to the subject. Loupes are classified by the optical method in which they produce magnification. There are three types of binocular magnifying loupes: 1) a dioptre, flat plane, single lens loupe, 2) a surgical telescope with a Galilean system configuration 3) a surgical telescope with a keplarian system configuration.

The dioptresystem relies on a simple magnifying lens. The degree of magnification is usually measured in dioptres.The prism loupes (keplarian system) use refractive prisms and they are actually telescopes with complicated light paths, which provide magnification up to 6x.The surgical telescope produce an enlarged viewing image with a multiple lens system positioned at a working distance between 11 and 20 inches .The prism and Galilean system produce superior magnification, correct spherical, and chromatic aberrations and have excellent depth of field and are capable of increased focal length thereby reducing both eyestrain and head and neck fatigue.

Disadvantage: Practical maximum magnification achieved by loupes is only about 4.5X and loupes with higher magnification are heavy and unwieldy with limited field of view.[2]

The operating microscope in dentistry:

To achieve higher magnification than loupes Gary Carr [3,4]introduced an operating microscope with Galilean optics in 1991which was ergonomically configured for dentistry with several advantages that allowed for easy use of the scope for nearly all endodontic and restorative procedures.It had a magnification changer that allowed for five discrete magnifications (3.5-30x), had a stable mounting on either the wall or ceiling, had angled binoculars allowing for sit-down dentistry, and was configured with adapters for an assistant’s scope and video or 35 mm cameras.It utilized a confocal illumination module so that the light path was in the same optical path as the visual path and this gave far superior illumination than the angled light path of the earlier scope.

Parts of operating microscopes:
The head of the microscope has three main parts:
1) Body tube optics
2) An eye piece lens
3) An objective lens

Eye piece is the one through which the operator views & the objective lens is towards the patient. The eye piece lens & the objective lens are two convex lenses (lenses are thicker at the centre& narrower at the edges.

- **Eyepiece**: eye piece plays an important role in magnification. Together with the focal length & the magnification change factors, they provide the desired magnification.
- **Binoculars:** the function of binoculars is to hold the eyepieces. The binocular projects an intermediate image into focal plane of the eyepieces. It comes in different focal lengths. Longer the focal length, greater the magnifications, narrower the field of view.[5]
- **Objective lens**: The focal length of objective lens determines the operating distance between the lens and the surgical field. Objective lenses are available with focal length ranging from 100 to 400 nm.[6]

Operator Positioning:
During the treatment procedure in dentistry operator's position should be in such a way which will simplify treatment and provide better ergonomics.The correct operator position for nearly all endodontic procedures is directly behind the patient, at the 11- or 12-o'clock position. Positions other than the 11- or 12-o'clock position (e.g. 9-o'clock position) may seem more comfortable when first learning to use an OM. But as greater skills are acquired, changing to other positions rarely serves any purpose. Clinicians who constantly change their positions around the scope are extremely inefficient in their procedures. The operator should adjust the seating position so that the hips are 90^0 to the floor, the knees are 90^0 to the hips, and the forearms are 90^0 to the upper arms.[7]The operator's forearms should lie comfortably on the armrest of the operator's chair, and feet should be placed flat on the floor. The back should be in a neutral position, erect and perpendicular to the floor, with the natural lordosis of the back being supported by the lumbar support of the chair. The eyepiece is inclined so that the head and neck are held at an angle that can be comfortably sustained. This position is maintained regardless of the arch or quadrant being worked on. The patient is moved to accommodatethis position. After the patient has been positioned correctly, the armrests of the doctor's and assistant's chairs are adjusted so that the hands can be comfortably placed at the level of the patient's mouth. The trapezius, sternocleidomastoid, and erector spinae muscles of the neck and back are completely at rest in this position.Once the ideal position is established, the operator places the OM on one of thelower magnifications to locate the working area in its proper angle of orientation. The image is focused and stepped up to higher magnifications if desired.[8]

Prerequisite for operating microscope:
Rubber dam placement:
The placement of a rubber dam prior to any endodontic procedure is an absolute requirement for sterility purposes. In endodontics, however, the purpose is greater. Here, the rubber dam placement is necessary because direct viewing through the canal with the microscope is difficult, if not impossible. A mirror is needed to reflect the canal view that is illuminated by the focused light and magnified by the lens of the microscope. If the mirror were used for this purpose without a rubber dam, then the mirror would fog immediately from the exhalation of the patient. Thus, the powerful microscope magnification and illumination would be rendered totally useless for the necessary visualization of the chamber floor and the canal anatomy. To absorb reflected bright light and to accentuate the tooth structure, it is recommended to use blue or green rubber dams

Indirect view and patient head position:
It is nearly impossible to view the pulp chamber directly under the microscope. Instead, the view seen through the microscope lens is a view reflected by way of a mirror. To maximize the access and quality of the view by this indirect means, the position of the patient (especially the head position) is important. The optimum angle between the microscope and the mirror is 45^0, and the clinician should be able to obtain this angle without requiring the patient to assume an uncomfortable position. The maxillary arch is rather easy for indirect viewing. Basically, the patient's head is adjusted to create a 90^0angle between the maxillary arch and the binocular. In this position, the mirror placement will be close to 45^0 for best viewing.[9]

Endodontic Microsurgical instrument –
Endodontic microsurgical instrument are specifically designed for microsurgery.

- The examination instrument includes the mirror, periodontal probe, explorer and micro explorer.
- Instrument used for incision and elevation include a 15C blade and handle and soft tissue or periosteal elevators.
- Curettage Instrument includes a minijacquette 34/35 scaler, a Columbia 13-14, and minimolten and miniendodontic curettes.

Mouth mirror placement:

It is always a good idea to use the best mirror for this purpose. The micro mirror is best for endodontic microsurgery. Micro mirror with blue handles have scratch-free sapphire mirror surfaces. Importantfeature of the mirror neck is flexibility. If a rubber dam has been placed, then the mirror must be placed away from the tooth within the confines of the rubber dam. If the mirror is placed close to the tooth, then it will be difficult to use other endodontic instruments. Readjusting the mirror will necessitate refocusing of the microscope, making the entire operation time-consuming and, at times, frustrating. This is especially true during a lengthy perforation repair. With practice, however, the‘ ‘correct’’ placement of the mirror will become automatic.[9]

Use of operating microscope in dentistry and endodontic:

A clinician must consider the benefit/risk ratio when using the microscope. The following procedures are those that are done and benefited from the use of the microscope.

Diagnosis:

The microscope is an excellent instrument to detect microfractures that cannot be seen by the naked eye or by loupes. Under 16x to 24x magnification and focused light, any microfracture can be easily detected. Methylene blue staining of the microfracture area assists this effort greatly. A persistently painful tooth after endodontic therapy may be due to an untreated missing canal (e.g. MB2 in a maxillary molar). Re-examination of the chamber at high magnification under the microscope may locate the missing canal.[9]

Identification and removing 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 with the help of a dental operating microscope.[17]

Locating hidden canals:

The most important utility of the microscope in nonsurgical endodontics is locating hidden canals. The canal anatomy is extremely complex., it has beenfound that nearly an 50% of all molars (maxillary and mandibular) have a fourth canal, more than 30% of all premolars have a third canal, and close to 25% of all anterior teeth have two canals. What was considered a rare exception in the past has become a routine finding when using the microscope. Considering this as the benefit of using the microscope for endodontic procedures is obvious. There are teeth where the canal bifurcates at 3 to 5 mm into the canal .In the maxillary second molar, where the MB and DB are in very close proximity of each other; the microscope is an invaluable tool in clearly detecting the bifurcation and the two separate canals.[9]

In open apex-

Modern apexification therapies need special treatment techniques and materials, which can be facilitated by manipulation under a dental microscope. [18]

Management of calcified canals:

With normal vision or low-power loupes, calcified canal in the pulp chamber is not detectable. When the calcified canal is looked at through the microscope at high magnification, the difference in the colour and texture between the calcified canal and the remaining dentin can be easily seen. Careful probing and ultra-sonicationusing CPR will allow clinicians to detect and negotiate the calcifiedcanal easily. Sometimes in these cases, the ultrasonic preparation of the canal or canals has to go as far as a couple of millimetres short of the apex. Again, the microscope allows the clinician to detect and prepare conservatively, and not to gouge the healthy dentin structures.[9]

Perforation repair:

Perforation does occasionally occur no matter how carefully the tooth is accessed for endodontic therapy. When a perforation occurs, the microscope is the key instrument to identify and evaluate the damaged site. The results of a careful inspection will be the basis for which the preparation of the perforation repair will be made. Briefly, the microscopic procedure is to place a matrix precisely,just outside of the perforation site.

The matrix can be calcium sulphate or resorbable collagen. After the matrix is placed, mineral trioxide aggregate is packed against the matrix. Thisprocedure requires delicate and careful handling of the materials so as not to extrude, overfill, or under fill.[9]

Removal of fractured post –

The enhanced vision with magnification and illumination from a microscope allows endodontics to observe the most coronal aspect of fractured post and to remove them without any major loss of tooth structure and perforation, the prognosis for preservation of tooth is good .[19,20]

Retrieval of broken files:

With the more frequent use of nickel-titanium rotary files in endodontics, the incidence of file separation within the canals has increased. When the file is broken at the apex, the microscope cannot be of help. If the file breaks within the coronal half of the canal, however, then the microscope is essential to guide the clinician to retrieve the broken files. In this manner, the broken file can be removed while minimizing the damage to the surrounding dentin.[9]

Final examination of the canal preparation

It takes a simple step to see whether a canal is completely cleaned. Under the microscope, a small amount of sodium hypochlorite, a popular irrigation solution, is deposited into the canal and observed carefully at high magnification. If there are bubbles coming from the prepared canal, then there is still remnant pulp tissue in the canal. In short, the canal needs more cleaning.[9]

Cost versus patient benefit:

Dental practitioner who does not have dental microscope used to evaluate the benefits of surgical operator microscope with capital expenditure and the cost and time associated with training. To address this issue, the best way is an intensive training course at the very beginning to make them comfortable with handling the microscope and with working underneath it. Use of SOM for each and every case is the fastest route toward proficiency and the best way to maximize the return on investment. After the initial learning curve, endodontic procedures can be done in less time because of the greater visibility of the root canal anatomy. Procedural errors can be greatly reduced, if not eliminated, and complicated cases become less so under the microscope. Another benefit of the microscope is the flexibility with documentation. Compared with intraoral video cameras, micro dental images can be captured on computer or digital camera. The information can then be shared with referring dentists or patients and the images are, of course, also required information for the patient record.[9]

Difficulty with operating microscope-

Common difficulty in the use of operating microscope:

1. High magnification
2. Changing technique
3. Lack of practice

High magnification-

There is a tendency to use a magnification which is too high. A fundamental optical principle is that the higher the magnification, the narrower the field of version, and the smaller the depth of the field. This concept is important because when higher magnification is used, surgery becomes more difficult, especially when it involves considerable movements. The magnification should be that with which the surgeons can operate with ease and without increasing their usual operating time for that surgical procedure.[12]

Changing technique-

There is consistent failure by operators to emphasize that the advantage of the operating microscope are not only in research and new operations or new instrumentation, but in the ability to perform conventional periapical surgery with greater precision and accuracy. It therefore follows that the with the use of the operating microscope, operators need not change their technique and they should continue to use the technique with which they are most familiar.[10,11]

Lack of practice-

With the operating microscope ,the operator have to change from “mobile” to “static” operators and they have to adjust to being prisoners within a narrow field of vision. A new –coordination has to be developed between the operators eyes and hands ,an adjustment which can only come from regular practice with simple surgical procedures.[12]

II. Conclusion

The operating microscope has revolutionized the speciality of endodontics. It represents a quantum leap in the development of competence for endodontics and dentistry in general. The increased magnification and the co- axial illumination have enhanced the treatment possibilities in non-surgical endodontics. Treatment modalities that were not possible in the past have become reliable and predictable

We can state microscopes in endodontics represent what the discovery of X-ray radiations represented for dentistry more than 100 years ago. As today we cannot imagine a dental office without the x-ray machine, in the same way we can state that the day is not far away when dentistry will be entirely and diffusely performed under the operating microscope. All endodontic graduate programs are now teaching its use as part of their curriculum. The only limitation that exists for the operating microscope is the imagination and it's certainly a most useful adjunct in the continual search for endodontic excellence.

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