Magnification In The Operative Field Of Dentistry : A Narrative Review

ABSTRACT:

In dentistry, magnification is introduced by the dental loupes and the dental operating microscope. However its acceptance and application is taking time. It is essential for us to understand what is magnification and its relevance in operative field of dentistry. A dentist's main purpose for investing in magnification , especially a microscope is usually for better precision. However, along with clarity they benefit from excellent ergonomics, patient communication tool and high intensity lighting. Magnification can change the quality of work in different branches of dentistry.

Keywords: dentistry, magnification, loupes, surgery

INTRODUCTION :

"Magnification and illumination are important to be able to visualize smaller, less invasive procedures. The concept of Microdentistry, minimally invasive care, was first introduced to the dental profession in the early 1990's and has been steadily adopted and grown ever since. Microdentistry promotes early diagnosis of disease with minimally invasive treatment".[1]

"The clarity and details achieved with magnification are so clear and revealing that clinician will immediately recognize the potential for improved accuracy in diagnostic and treatment. It is well said that a magnified clear image can speak more for itself than a thousand words put together".[2]

"Dentists often perform treatments that require more satisfaction than a healthy eye. The use of magnification enables the visualization of fine details of the operating field and has a positive effect on the ability to diagnose and restore dental lesions. Procedures frequently performed with magnification devices include placing margins for restorations, treating radicular furcations, and bone grafting".[3]

HISTORICAL BACKGROUND:

In the late 1800s, the first magnifying devices to aid in surgery were introduced to the medical field. However, the first surgical microscope OPMI 1 was introduced in 1950. Invented and commercially marketed by the Carl Zeiss Company, this device had options for coaxial illumination and stereoscopic viewing. However, this instrument failed to gain the acceptance of the medical fraternity due to its poor configuration and very long focal length. The first microscope for dentistry was introduced in 1978 by Apotheker and Jako. In endodontics, microsurgery has been practiced since 1986. In 1992, microsurgery was also introduced into periodontics. [4]

TYPES OF MAGNIFICATION SYSTEM :

Broadly speaking, the concept of magnification enhanced dentistry includes the use of two types of optical magnification systems:

a) loupes

b) surgical operating microscope

The various types of loupes are:

- Simple loupes
- Compound loupes
- Galilean loupes

• Prism loupes [2,4].

Working Principle Of Loupes :

There are several optical principles that are important to the wearer, particularly related to the magnifying loupes :

1. The field of view
2. The depth of field
3. The declination or viewing angle
4. Individual loupe design, including co-axial illumination

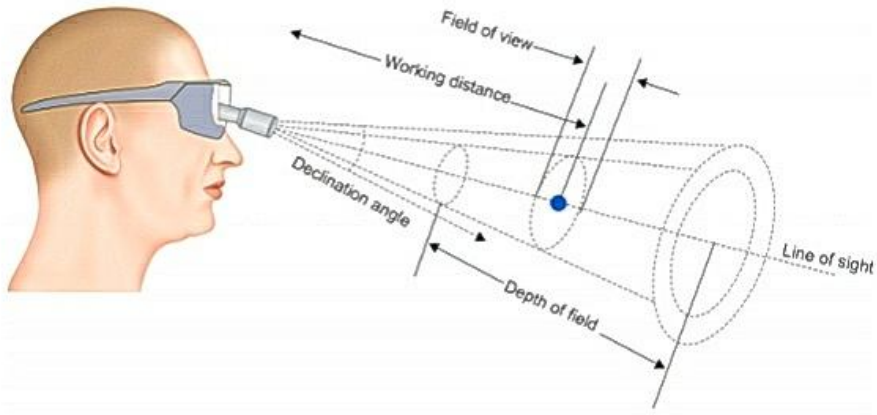

Fig 1: {Magnification loupe features (adapted from James T and Gilmore, 2010)}

Field Of View :

As magnification increases, the field of view decreases. It is possible to obtain loupes that magnify by as much as 6x. However, in practical terms, a magnification of 2x–2.5x will enable the dental operator to see multiple quadrant areas in focus. This is the magnification commonly used in general dental practice and is recommended for new users. At 3.5× magnification the field is limited to one quadrant, while beyond 3.5× magnification the view become increasingly restricted until only a single tooth is visible. This makes high magnification unsuitable for routine operative dentistry, but is useful when performing specific procedures such as endodontics.

Depth Of Field :

Depth of field is the ability of the lens system to focus on both near and far objects without changing its position. For normal vision, it ranges from the working distance to infinity. The use of magnification limits the depth of field, and as the magnification increases, the depth of field decreases to the point where only a small object is in focus and everything around is out of focus. At high magnification, slight movements of the operator or patient will reduce focus on the examination area, making the task more difficult.

Declination (Viewing) Angle :

“This is the angle at which the lens is set to a horizontal reference line that is drawn from the upper auricular crevice to the bridge of the nose and defines a slight line. When operating, the greater the angle with respect to this line, the greater the neck tilt required to view the object. It is practically important to ensure this angle is correct for the individual to reduce stress on the neck, back and shoulders”. [5]

Loupe Design :

The various types of loupes are:

- Simple loupes
- Compound loupes
- Galilean loupes
- Prism loupes [4]

Dental Operating Microscope :

In the past, standard microscopes determined the focal length based on the observer's height and working position. Since then, these microscopes have undergone various advancements and modifications.

The basic components of an operating microscope are as follows :

- Binoculars
- Microscope body with magnification and fine focus adjustments
- Light source

Microscope Body :

The body of the microscope is made up of three parts –

1. The upper segment has a dovetail receptacle with a knurled clamping screw to hold any accessories or binocular tubes
2. The middle segment has a magnification adjusting device
3. The lower section has a threaded dovetail receptacle for front sighting

Binoculars :

Using the same principle as a telescope in a telescope tube setup allows a stereoscopic view to be applied to the field glass. The lower threaded dovetail receptacle ensures alignment of the telescope tube with the body of its optical axis with the help of clamping screws. Variable inclinable tubes are available in the binocular from 0 to 220˚ to accommodate any head position. Interpupillary distance is adjusting the distance between the two-binocular tubes. The binocular tubes can be adjusted inward or outward depending on the pupillary distance of the individual concerned.

Light Source :

An important aspect of a precision dental operating microscope is the light source as it helps to illuminate the deepest part of the root canal. Light can enter the canal at any angle, but must be perfectly coaxial with the operator's view, to avoid shadows. [6]

To appreciate what a surgical microscope can do, it's important to understand how it works. The main parts can be divided into 3 groups :

1. Magnification
2. Illumination
3. Accessories

Magnification :

Magnification is determined by :

a. Eyepieces
b. Magnification Changer
c. Objective Lenses

Eyepieces – that are available in 6.3×, 10×, 12.5×, 16×, 20× power. It consists of

1) A viewing side with rubber cup

2) Adjustable diopter setting (-5 to +5).

3) Binoculars – it is used to hold an eye piece which can be straight, inclined or tilted and again of shorter or longer focal length.

Magnification Changer – which can be 3/5 step manual changer or power zoom changer.

Objective Lenses – whose focal length determines the operating distance between the lens and the surgical field.

Illumination :

This is mainly done by a 100 watt xenon halogen bulb, where the intensity is controlled by a rheostat and cooled by a fan. The illumination is mainly co-axial with the line of sight, which means that the light is concentrated in the eyepieces so that no shadows are visible. This is made possible by the use of Galilean optics.

Accessories :

1) Pistol or bicycle grips

2) Liquid crystal display (LCD) and high resolution monitors which receives video signals from cameras.

3) Integrated video camera

4) Eye piece with rectile field: used for aligning during video taping and 35 mm photography.

5) Auxiliary monocular or articulating binocular for dental assistant. [7]

ENDODONTICS :

Endodontists have always tried to improve the vision of the operating field. The human unaided eye with a resolving power of 0.2 mm is capable of identifying fine details when the image is sharpened and magnified to effectively enhance the area of interest for proper diagnosis and treatment of various dental pathologies. In dental loupes, surgical loupes were used from the 1870s and binocular loupes were added to spectacles in the 1900s. magnification of the loup ranges from 2× to 6×.

Classification of Loupes

1. Based on the number of lens

• Single lens

• Multiple lens

• Galilean optic loupes

• Prism loupes

2. Based on the magnification system

• Flat plane, single lens loupes

• Surgical telescope with Galilean optical system

• Surgical telescope with Keplerian optical system

3.Based on the design of loupes

• Through the lens loupes

• Flip-up loupes

A rod lens provides greater magnification than a loupe. It consists of glass rods. Also it consists of a camera, a light source and a monitor. A disadvantage of rod lens endoscopy is that the instrument is rigid, so it cannot be used for visualization of curved root canals.

An orascope is a fiber optic endoscope designed for intracanal visualization. Image quality is directly related to the number of fibers and the size of the lens used. Orascope is composed of 10,000 parallel visual fibers. The visual fiber is between 3.7 µm and 5.0 µm in diameter. It has a 0.8-mm tip diameter, 0° lenses, and a working portion of 15 mm in length.

“Head-mounted microscope 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”.[8]

“In conventional endodontics, improvement of visual acuity and illumination is facilitated:

• The identification and subsequent access of accessory anatomy • The negotiation of sclerozed canals • The identification and removal of dystrophic calcifications, such as pulpal stones • Ensuring improved quality of canal obturation and thereby creating an effective coronal seal • The identification and subsequent repair of perforations and resorptive defect • The retrieval of separated endodontic instruments and fractured posts” [3].

RESTORATIVE DENTISTRY :

It has been proven that dentists perform better restorative treatments under the microscope because of the accuracy of the diagnosis and the correct completion of the treatment steps. A magnified image of the operative field can help the dentist examine cavity preparations, matrix fitting, saliva infiltration, remaining dentine debris, composite layering, occlusal morphology, macro/micro details, surface texture of restoration, air voids, impurities and over-contours in a better way.

“The benefits of magnification in restorative dentistry treatments are important in the following situations : • Identification of areas where the enamel tissue is demineralized; • Identification and minimally invasive removal of old restorations; • Inspection of caries borders and remaining carious tissue; • Identification of enamel cracks and fissures; • Checking on the sectional matrix adaptation and controlled application of liner; • Minimally invasive preparation of small Class III cavities; • Evaluation of the marginal gaps of the restorations; • Gaps or impurities in restorative materials; • Removal of excess composite materials; • Management of small, accidental pulp chamber openings without mechanical injury to the pulp”. [9]

PROSTHODONTICS :

A dental operating microscope can be used for thorough tooth preparation, but some dentists use a loupe to make a gross reduction of the tooth structure before using the microscope to complete the preparation. Gross reduction of tooth structure is accomplished using medium magnification (6.4x to 10x), and margins are completed using 16x magnification. An important advantage of high magnification is the ideal placement of crown or veneer margin. The entire field of view is covered by one tooth, in contrast to the high magnification of medium magnification. At high magnification, only part of tooth is visible at a time. The advantage of using higher magnification is the reduction of peripheral “visual noise.” At 16× magnification, the image has a 100% operating field and the clinician’s concentration is not affected by peripheral distractions.

When using the operating microscope efficiently to prepare crowns and bridges, the instrument remains stationary and the patient’s head position changes and dental mirror allows optimal viewing. The use of higher magnification provides the clinician with a more detailed view of the preparation margin, but there is a corresponding reduction in the width and depth of the operating field. A good general rule is to use 10x magnification for the completion of tooth preparations.

After completion of final margin, another advantage of the operating microscope is improved tissue management. The provisional restoration can be trimmed under a microscope, ensuring that the restoration adapts well and will allow the tissue to heal in the provisional phase.

Once the impression reaches the laboratory, it is ideal if the laboratory uses magnification when fabricating the prosthesis. Several types of high magnification are available for this purpose, allowing work to proceed under 10× to 40× power.

During try-in and seating appointments, the microscope is extremely helpful. Visualization of the crown fit using 10× magnification further improves the ability to determine whether the margin is acceptable.

The actual interproximal contact can be seen at high magnification as a bright spot on the sandblasted surface. For porcelain crowns, waxed floss leaves a waxy residue on contact, which is again will be visible under high magnification and easily and specifically adjusted.

“Translucent resins are particularly difficult to see and in most cases, a microscope facilitates removal of excess. . The cementation of full coverage restorations is also improved when using the microscope, as minute amounts of cement can often be seen and easily removed”. [10]

PERIODONTICS :

The latest concept of micro dentistry applied to periodontics is the use of a miniaturized dental endoscope called the Perio-scope for both diagnosis and treatment of periodontal conditions. Perioscopy, formerly called periodontal endoscopy, is a procedure that combines a miniature dental endoscope with advanced video, lighting and magnification technology and is sub-gingival for easy visualization and therefore enables to diagnose and treat the sub-gingival area as conservatively as possible. The device used, called a Perio-scope, uses fibre- optic technology to illuminate the periodontal pocket and provide a clear and magnified view of the root surface and inaccessible areas such as tri-furcations and bi-furcations. The Perioscope can also be used to detect sub-gingival calculus remnants, ulcerated sulcular epithelium, cemental perforations and disturbed sinus drainage pathways.

Indications :

- Any periodontal condition with a probing pocket depth (PPD >4) of greater than 4mm
- Magnified visualization of sub-gingival calculus attached to the root surfaces that can be debrided with specialized miniature periodontal micro-surgical instruments
- Arbitrary root deformations and anatomical variations can be visualized and tracked along their path and ultimately restored without any recurrence
- All complications resulting from recession and root exposure for major periodontal surgery through an open access flap are avoided by microsurgery
- Teeth diagnosed with Refractory Periodontal disease and those with chronically inflamed pockets and increasing pocket depths are ideal
- Teeth with poor prognosis and minimal access to defects- under furcations
- Avoidance of second surgery in implant mucositis and peri-implantitis of diseased implant surface plays a role in early resolution of peri-implant infection
- Patients in whom periodontal surgery is contraindicated due to their medically compromised health status
- Ultimately long term treatment outcomes are improved by the use of minimally invasive procedures that minimize trauma to healthy surrounding tissue while effectively treating the disease [11]

ORAL AND MAXILLOFACIAL SURGERY :

Microscope-level magnification (6x to 8x or greater) combined with head-mounted, co-axial illumination, can improve a dentist’s ability to perform tooth extractions. Even if only a small portion of the tooth particle is exposed and the rest is covered by gingiva, the presence of the tooth particle can be clearly seen by examining that small area under 6× to 8× magnification. Although the tooth is completely covered by the gingiva, there is a microscopic perforation of the gingiva on the tooth due to drainage path of the abscess that drains along the tooth. Examination of the field at 6× to 8× magnification reveals this slight staining in the gingiva, in turn exposing the tooth particles. It is useful for locating the third root of a maxillary molar when the other two roots are visible.

Microscope-level magnification allows the dentist to detect subtle differences in how the elevators are positioned at various points along the perimeter of the tooth. Microscope-level magnification allows the dentist to detect if a specific method of placing the elevator at a point along the perimeter of the tooth causes subtle incremental improvements in the luxation of the tooth when dentist applies pressure to the elevator. The microscope allows the dentist to reproduce in detail a specific method of

placing the elevator at a specific point along the perimeter of the tooth when the dentist finds that such placement improves the movement of the tooth.

A magnified view of the clinical crown of the tooth helps to visualize the location of the long axis of the tooth and to estimate the unseen location, subgingival roots and furcations between them. It also facilitates the orientation of the surgical carbide bur so that the axis of the bur is parallel to the long axis of the tooth when dividing furcations. Magnification also reveals subtle topographical curves on the outer surface at the cemento-enamel junction, indicating where the tooth root surface slopes into the furcation area. Magnification and co-axial light aid in determining whether there is complete division of the roots in the furcation. A magnified view of elevator luxation movement of split roots shows whether the roots are moving independently in response to the luxation force or whether two or three roots are moving together as a unit, which would indicate incomplete dissection of the furcation tooth structure. Microscope-level magnification makes it easy to distinguish the furcation tooth structure and the apical alveolar bone of the furcation, and the furcal tooth structure and alveolar bone along the buccal, lingual, mesial and distal walls of the socket.

A microscope-level view of the angle of approach of the working end of the elevator allows the dentist to create an angle in three-dimensional space to drill into the tooth that matches the angle of approach of the working end of the elevator.

Microscopic-level magnification is also useful when removing tooth or bone tissue that facilitates extraction of single tooth roots without furcation, such as premolar root tips or individual roots of sectioned molar teeth. Microscopic-level magnification facilitates visualization of the recesses in the root structure where alveolar bone grows, requiring the dentist to drill this alveolar bone to increase the degree of freedom of tooth root movement in response to luxation forces. Microscope-level magnification allows the dentist to section a vertical sliver of the tooth root, to a depth of one centimeter or more, into the extraction socket, thereby increasing the buccal or lingual space between the tooth root and the tooth wall. Magnification also facilitates identification and removal of supra-coronal tooth structure that overlaps adjacent tooth structure to increase the degree of freedom of root movement in response to luxation forces.

Microscope-level magnification allows the dentist to see subtle differences in how the forceps grip the tooth and the direction of force the forceps apply to the tooth.

Microscopes can improve the dentist's ability to control tooth extraction pain.[12]

PEDODONTICS :

"Laser technology allows the dentist to perform microdentistry, with early detection and diagnosis, treating only the affected tissue and preserving healthy tooth structure, thus fulfilling the motto. Nd:YAG or diode lasers can be used for the treatment of infected root canals. The bactericidal effect within the root canal is around 99%. Er:YAG and Er, Cr:YSGG laser are effective for removing organic materials and smear layer within the root canal. Laser-supported pediatric dentistry is one of the most promising fields in modern minimally invasive dentistry".[13]

ORTHODONTICS :

Orthodontic therapy with brackets ends with two stages – debonding and clean-up – removing the brackets and finishing and polishing the enamel surface. Removal of resin from the enamel surface after debonding is important and can affect the patient's aesthetics and oral health, especially when considering plaque accumulation.

Available debonding and clean-up techniques cannot completely clean the vestibular surface of teeth and can cause temporary changes in the underlying enamel morphology visible to the naked eye.

“Magnification of the smallest details is a particularly important factor during the debonding process, in order to save as much enamel tissue as possible during adhesive removal”.[14]

CONCLUSION:

Microscope-enhanced dentistry is changing endodontic-restorative protocols, changing the thought process when deciding when to save or extract a tooth. Microscopes offer additional methods for caries assessment and endodontic therapy, bringing the profession closer to zero-defect restorative dentistry. With advanced magnification, the additional visual information afforded to the dentist with shadow-free, coaxial light, corrected optics enhances dentist’s ability to create clean erosion-free margins which, in turn, can create an optimal restorative seal. Accurate vision is essential for accurate therapy. High-quality endodontic therapy is the basis for long-term function and biologic success, allowing patients to remain pain-free. Low-magnification in clinical accuracy to tactile-driven dentistry is revolutionizing the field of dentistry with higher success rates by changing to vision-bases dentistry.

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