

Magnification Tools: Surgical Operating Microscope And Magnifying Loupe In Dental Practice

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Abstract:

Magnification is an apparent increase in size especially by the use of lenses.

History of the Magnification dates back to 1694 when Anton van Leewenhock constructed first compound lens microscope. Optical magnification has broadened the horizons of dentistry in general, and Periodontology, Restorative dentistry and Endodontics in particular. Various magnification systems used in dentistry include Dental Loupes & Surgical Operating Microscope. Magnification tools are utilized in routine dental practice for diagnosis, esthetically demanding prosthetic restorations, routine endodontic procedures, non- surgical periodontal procedures, periodontal plastic microsurgeries, implant dentistry etc for better visualization, improved treatment quality and ideal treatment ergonomics enhancing motor skills to improve surgical ability by maintaining the right posture. Minimally invasive dental procedures with ease and precision are possible today with the use of magnification in dental practice.

Key words: Magnification, Dental Loupes, Surgical Microscope, periodontal microsurgery.

Introduction

Visualisation of fine details is enhanced by increasing the image size of the object. Image size can be increased by getting closer to the objects or by magnification. Magnification increases the focal length in order to see small objects accurately, which in turn increases the working distance between the eye and the object allowing, extra-ocular muscles to remain more relaxed and a dentist to maintain normal posture.

In dental practice, the tissues to manipulate are usually very fine resulting in a situation in which the natural visual capacity reaches its limits. Therefore, the clinical procedure may be performed successfully with the use of magnification improving precision and, hence, the quality of work¹.

Historical background

References to magnification date back to 2,800 years, when simple glass meniscus lenses were described in Egypt.

- Anton van Leeuwenhook, 1694 – constructed first compound lens microscope².

- 1876- magnification was introduced to dentistry.³
- Nylen, 1922 – first performed eye surgery under a microscope.^{4,5}
- Barraquer, 1950s- began using microscope for corneal surgery.⁶
- Jacobsen & Suarez, 1960 – obtained 100% patency in suturing 1 mm diameter blood vessels for anastomosis⁷
- 1960s – microsurgery was standard in many specialities such as neurology & ophthalmology.^{8,9}
- 1970s & 1980s - First articles about using a microscope in Odontology Dentistry were published.¹⁰⁻¹³
- Apotheker & Jako, 1978 – first introduced the microscope to dentistry.
- 1986 – microsurgery has been practiced in endodontics.¹⁴
- 1990s - systematic use of surgical microscopes started and was applied by the different odontological dentistry specialities¹⁵, such as Periodontal Surgery.¹⁶
- Carr, 1992- published an article outlining the use of a surgical microscope during endodontic procedures¹⁴.
- Shanellec & Tibbetts, 1993 – Presented a continuing education course on periodontal microsurgery at the annual meeting of the American Academy of Periodontology.¹⁶
- 1994—The first microscopes were routinely used for restorative dentistry.¹⁷
- 1999—The American Association of Endodontists required all endodontic graduate students to be microscope proficient.¹⁷
- 2002—The Academy of Microscope Enhanced Dentistry is formed.¹⁷
- 2005—Several dental schools integrate microscopes into undergraduate programs.¹⁷

Principles of magnification

Two basic types of magnification systems are commonly used:

1. Loupes
2. Surgical microscope

1) Optical principles of loupes^{3,16,18}

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

angled to focus an object. The magnified image that is formed has stereoscopic properties that are created by the use of convergent lens systems.

Loupes are further classified as:

- (1) Single-lens magnifiers (clip-on, flip-up, jeweller's glasses) and
- (2) Multi-lens telescopic loupes.

(1) **Single-lens magnifiers** (Fig.1) produce the described diopter magnification that simply adjust the working distance to a set length. As diopters increase, the working distances decrease. A set working distance creates difficulty in maintaining focus and, therefore, may cause neck and back strain from poor posture^{19,20,21}.

(2) **Telescopic loupes (compound or prism loupes)** (Fig.2) - compound loupes use multiple lenses with intervening air spaces which allow an adjustment of magnification, working distance, and depth of the field without excessive increase in size or weight.

Prism loupes are the most optically advanced type of loupe magnification, offering improved ergonomic posture as well as significant advancements in optical performance³. They contain Pechan or Schmidt prisms that lengthen the light path through a series of mirror reflections within the loupes

Optical features of loupes (Fig.3)

1. **Working distance** - is measured from the eye lens location to the object in vision¹, or is the distance between the plane of the eye and the surface being treated.²² Working distance with slightly bended arms usually ranges from 30 to 45 cm. At this distance, postural ergonomics are greatly improved and eye strain reduced due to lessened eye convergence.^{23,24}

One way to measure it is to ask the clinician to adjust the second hand on their watch while holding their arm at midline or heart level. It is important that clinician remember their own working positions, and not match those prescribed. The correct working should never allow for overextension of the neck, chin, or shoulders.²²

1. **Working range** (depth of field) is the range within which the object remains in focus¹ or, within which one is able to maintain visual accuracy at the appropriate working distance.²² Normally, eye position and body posture vary constantly. Wearing loupes changes this geometry, as the body posture and position of the extraocular muscles are

confined to a range determined by the loupe's characteristics¹. The proper depth of field allows the practitioner to avoid too much leaning and any overextension while practicing²². With any brand of loupe the depth of field decreases as the magnification increases.

2. **Convergence angle** - is the pivotal angle aligning the two oculars, such that they are pointing at the identical distance and angle. At a defined working distance, the convergence angle varies with interpupillary distance. A preset convergence angle as well as preset interpupillary distance is more user friendly, since they should not be changed once correctly positioned. Whereas an adjustable interpupillary distance allows the loupe to be used by more than one person.²⁵
4. **Field of view (Width of field)** - is the linear size or angular extent of an object when viewed through the telescopic system¹ or, represents the width and height of the area the practitioner sees while using the magnification device. The higher the magnification, the smaller the width of field.²²
5. **Interpupillary distance** - depends on the position of the eyes of each individual and is a key adjustment that allows long-term, routine use of loupes. The ideal setting, as with binoculars, is to create a single image with a slightly oval-shaped viewing area.¹
6. **Viewing angle**
The viewing angle is the angular position of the optics allowing for comfortable working. The shallower the angle, the greater the need to tilt the neck to view the object being worked at. Therefore, loupes for dental clinicians should have a greater angulation than loupes designed for industrial workers. The ocular structure of the Designs for Vision loupe is small and lightweight and is physically secured to the lens of the glasses. The viewing angle is customized for each operator and then locked into position by building the magnifier into the lens. The ocular structures of Dimension Three loupes are front frame- mounted. These systems offer pivotal angle adjustments that can easily be altered and locked into position based on the wearer's comfortable working posture.²⁵

7) Illumination

Collateral lighting systems may be helpful for higher magnification in the range of 4X and more. Loupes with a large field of view will have better illumination and brighter images than those with narrower fields of view. Important considerations in the selection of an accessory lighting source are total weight, quality, and the brightness of the light, ease of focusing and directing the light within the field of view of the magnifiers, and ease of transport between surgeries²⁶.

Each surface refraction in a lens results in a 4% loss in transmitted light due to reflection. This could amount to as much as 50% reduction in brightness in telescopic loupes. Anti-reflective coatings have been developed to counteract this effect by allowing lenses to transmit light more efficiently. The quality of lens coatings also varies and should be evaluated when selecting loupes²⁵.

Optical principles of a surgical microscope (Fig.4)

The surgical microscope is a complicated system of lenses that allows stereoscopic vision at a magnification of approximately 4-40X with an excellent illumination of the working area. The light beams fall parallel onto the retinas of the observer so that no eye convergence is necessary and the demand on the lateral rectus muscles is minimal.

The advantages and four areas to be discussed are:²⁷

1. Magnification.
2. Illumination.
3. Documentation.
4. Accessories.

1) Magnification

Magnification is determined by the power of the eyepiece, the focal length of the binoculars, the magnification changer factor, and the focal length of the objective lens.

The optical unit includes the following components²⁸ (Fig.5)

I. Eyepieces Available in powers of 6.3X, 10X, 12.5X, 16X and 20X. For periodontal purposes generally 5X to 12 X suffices. Eyepiece diopter settings range from -5 to +5 and are used to adjust for

accommodation & refractive error. The eyepieces magnify the interim image generated in the binocular tubes. Eyepiece selection not only determines the magnification, but also the size of the field of view corresponding to the loupe spectacles.

II. Binocular tubes The precise adjustment of the inter-pupillary distance is the basic pre-requisite for the stereoscopic view of the operation area. The binoculars hold the eyepieces. The inter-pupillary distance is set by adjusting the distance between the two binocular tubes. Longer the focal length of binoculars, greater is the magnification and narrower the field of view. Binoculars can be straight, inclined, or inclinable tubes. Straight tube binoculars have tubes parallel to the head of the microscope. Inclined binoculars are orientated so that the tubes are offset at 45 degrees to the head of the microscope. Inclinable tubes are adjustable between the straight tube and the inclined tube positions and sometimes beyond 90 degrees.

III. Magnification changer The magnification changer consists of one cylinder, into which two Galilean telescope systems with various magnification factors are built. The combination of the magnification changer with varying objective lenses and eyepiece yields an increasing magnification line when the control is adjusted.

IV. Objective lens The focal length of the objective lens determines the operating distance between the lens and the surgical field. Variety of objective lenses is available with focal lengths ranging from 100 to 400 mm. A 175-mm lens focuses at about 7 inches, a 200-mm lens focuses at about 8 inches and a 400 mm lens focuses at about 16 inches.

A typical microscope package could be one with 12.5X eyepieces, 125-mm straight or inclinable tube binoculars, a power zoom magnification changer, and an objective lens of 200 mm. This package would allow a clinician to operate comfortably about 8 inches from the patient and in the magnification range of about 3 X to 26 X.²⁹

V. Lighting unit Optimal illumination is necessary with high magnifications. Light source is a 10-watt xenon halogen bulb providing a whiter light than conventional bulbs due to their higher colour temperature. As halogen lamps emit a considerable portion of their radiation within the infrared part of the spectrum, microscopes are equipped with "cold-light" mirrors to keep this radiation from the operation area. An alternative to the halogen light is the xenon lamp that functions up to ten times longer than the halogen lamp. The light has daylight

characteristics with even a whiter colour and delivers a brighter, more authentic image with more contrast.¹

2) Illumination²⁷

Light intensity is controlled by a rheostat and cooled by a fan. Light is then reflected through a condensing lens to a series of prisms and through the objective lens to the surgical field. After the light reaches the surgical field, it is reflected back through the objective lens, magnification changer lenses, binoculars and exit to the eyes as two separate beams of light. The separation of the light beams is what produces the stereoscopic effect that allows the clinician to see depth of field. Surgical microscope uses coaxial fiber-optic illumination producing an adjustable, bright, uniformly illuminated, shadow-free, circular spot of light that is parallel to the optical viewing axis.

3) Documentation²⁷

Photo and cine adapters provide the necessary focal length so that the cameras record an image with the same magnification and field of view as seen by the operator. As the 35mm camera gets only half the available light and due to the relative insensitivity of color photographic film, it is usually necessary to supplement the microscope's lighting system by adding a strobe over the objective lens. Strobe is a device used to produce regular flashes of light. Videotape is an extremely sensitive format and does not need supplemental light.

Video printers can be connected to a videocassette recorder or the video camera on the microscope. A microcomputer inside the video printer automatically analyzes the image, and prints are created in 70 seconds by a high density sublimation dye. Video prints can be used for patient education, medico-legal documentation, or reports to referring dentists and insurance companies.

4) Accessories²⁷

Pistol grips can be attached to the bottom of the head of the microscope to facilitate movement during surgery. Observation ports can be added to the microscope by a beam splitter and can be helpful in teaching situations. Auxiliary monocular or articulating binoculars can also be added and used by a dental assistant. Another accessory used to facilitate an assistant's viewing is the liquid crystal display screen. It is possible to record videos or take still images since it provides adaptable and integrated mounting options for video camera or digital and SLR cameras.

Magnifying optical systems have become an integral part of restorative dentistry. It has a wide scope for the permanent functional and various

esthetic restorative treatments. Due to shady illumination by the operatory lamp, any outcome oriented dentist reaches limits even with high magnifying loupe. With the introduction of dental microscope there has been significant increase in success rate.

In all areas of Endodontics from exposure of access cavity and preparation to three dimensional obturation and postendodontic management, microscope provides major advantages over working without appropriate magnification.

Magnification tools such as magnifying loupe and especially surgical operating microscope are useful in dentistry for various purposes such as diagnosis of subgingival deposits, microfractures, longitudinal fractures, defective margin fit of restorations etc that are often overlooked clinically. Magnification is often necessary to study root canal anatomy and the root surface in endodontics. Diagnosis of second mesiobuccal root canal of maxillary molar, extra root canal, C-shaped canals etc are extremely easy and accurate with the help of microscope leading to successful management of the case. Use of microscope is the best option for detection of perforations, localization of broken endodontic instruments in root canals, where visualization is the major problem. In general magnification can be set to between 4X and 24X thereby expanding the diagnostic options due to better lighting and sight. Repair of perforations can be done more accurately and reliably using variable and adjustable magnifications with shadow free light due to a coaxial radiating light source. Prognosis for major preservation of tooth structure without any major loss is the reality with surgical operating microscope.

Current digital visualization technology has advanced significantly in recent years. Dental microscope can offer integrated, efficient solution for daily practice and documentation. When coupled with the appropriate capture devices, microscope becomes an instrument for the projection and recording of clinical procedure in more streamlined and efficient manner.

For non-surgical periodontal therapy, vast array of modern instruments and equipments such as microultrasonics, Endoscope, LASERS are available to achieve a biologically acceptable root surface. The study was undertaken by the author to evaluate the effectiveness of scaling and root planing (SRP) under different magnifications using Magnifying Loupe [X

4.5] and Surgical Operating Microscope. [2.5X – 12.5X] It was proved from the analysis of results that magnification tools significantly enhance the efficacy of supra gingival and sub gingival scaling and root planing.

Key to aesthetic and functional success as well as predictability is the selection of a minimally traumatic approach which not only depends on surgeon's dexterity, but also on the perception of the human eye. Therefore, the use of magnification systems is essential to appropriately performing microsurgical techniques. There are various applications of magnification in surgical periodontics.

Microsurgery represents amplification of universally recognized surgical principles in which gentle handling of soft and hard tissue and extremely accurate wound closure made possible through magnification, allowing for well planned and precisely executed surgical procedures.¹⁸

Requirement of special instruments while working under magnification

Working with magnification tools requires specially designed instruments to keep fingers from getting in the way such as micro mirrors, micro explorers, micro restorative and endodontic instruments and hand spreaders instead of finger spreaders, rotary files instead of hand files in the field of Endodontics and minimally invasive restorative dentistry.

Proper instrumentation is fundamental for microsurgical intervention. As the instruments are primarily manipulated by the thumb, index and middle finger, their handles should be round, yet provide traction so that finely controlled rotating movements can be executed. The most commonly used precision grip in microsurgery is the pen grip which gives greater stability than any other hand grip. The instruments should be approximately 18 cm long and lie on the saddle between the operator's thumb and the index finger; they should be slightly top-heavy to facilitate accurate handling. In order to avoid an unfavorable metallic glare under the light of the microscope, the instruments often have a coloured coating surface. The weight of each instrument should not exceed 15-20 g (0.15-0.20 N) in order to avoid hand and arm muscle fatigue. Working tips of microsurgical instruments are smaller than the regular instruments. Needle holders and tissue forceps are made of titanium to provide consistent manipulation of the tissues. Such

instruments are resistant to distortion from repeated use and sterilization, non-magnetized and are lighter than the stainless steel instruments.

Suturing in Microsurgery³⁰⁻³³

Suturing is a critical factor in success of surgical dental treatment. Suture materials and techniques have evolved to the point that sutures are designed and developed for specific procedures. The criteria necessary for the successful use of suture materials are dependent on the surgical procedure to be performed and the factors necessary to successfully close the wound in a manner that promotes optimum healing. Ideally, the incisions should be almost invisible and closed with precisely placed, small sutures with minimal tissue damage and bleeding.

Advantages and Disadvantages OF Magnification

The magnification recommended for surgical interventions ranges from 2.5-20x.^{3, 12} In periodontal microsurgery, magnifications of 4-5X for loupes and 10-20X for microscopes appear to be ideal depending on the kind of intervention. Loupes have the advantage over the microscope in that they reduce technique sensitivity, expense, and learning phase. The lighting of the operation field is often insufficient and that may limit magnifications more than 4.5X. A clinician using loupes for magnification receives the ergonomic benefits of an increased working distance from the viewing object as well as increased visual acuity. Loupes allow maintaining less than 20 degrees of neck flexion. Working in postures with greater than 20 degree of neck flexion has been associated with increased neck pain³⁴.

However, increased magnification with loupes results in increased weight of the lenses, and reduced stability of the field of vision. The surgical microscope guarantees a more ergonomic working posture³⁵, optimal lighting of the operation area, and freely selectable magnification levels - The microsurgical triad². Because microscopes are external to the body, clinicians who use them are not affected by the weight of the instrument or the challenge of maintaining a stabilized field of vision. These advantages are countered by increased expenses of the equipment and an extended learning phase for the surgeon and his assistant. In order to visualize lingual or palatal sites that are difficult to access, the microscope must have sufficient maneuverability. Restricted area of vision, loss of depth of field as magnification increases, and loss of

visual reference points, are some of the drawbacks of magnification.

Loupes and Surgical microscope both allow clinician to perform tasks not possible without improved visual acuity; however, loupes cannot be compared to the comfort, versatility, illumination, and visual acuity offered by the microscope. Dental microscope makes it possible for the surgeon to sit in an ergonomically correct, relaxed and upright position during the treatment. A magnified microscopic image is worth more than the thousand words.

Infection Control ³⁶

Magnifying loupes collect debris from many procedures. Infection control is difficult at best. Ideally, all areas of the loupe should be disinfected with a high-level disinfectant after each patient. Disinfecting with ethyl alcohol solution is recommended. The telescopes are disinfected with alcohol (Isopropyl Alcohol 70% by volume).If the lenses are water resistant, products such as Lysol Disinfectant Spray (Reckitt Benckiser Professional, Wayne, N.J.) may be sprayed into a gauze sponge and used to wipe the frames and lenses before the procedure.

Conclusion

Use of magnification tools such as surgical operating microscope and magnifying loupe in dentistry not only improves the quality of care provided to patients, but also expands the range of treatments that can be offered. Various benefits of magnification are magnified image, brilliant illumination, better posture, improved comfort, increasing precision, improved dental care, and additional treatment options improving profitability. New era of micro dentistry, micro endodontics and micro suturing for various microsurgical procedures in dentistry is gaining popularity with magnification tools.

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Figure1. Simple Loupe



Figure 2. Prism Loupe

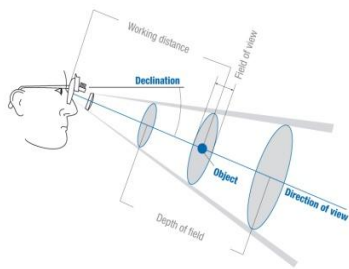


Figure 3. The principal optical features of loupe



Figure 4. Comparison of vision enhancement with loupes and a microscope.



Figure 5. Components of a surgical microscope

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