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Magnification in Dentistry: Literature Review

Gurleen Kaur [a], Gunmeen Sadanam [a], Rashu Grover [a*], Sunil Gupta [a], Teena Gupta [a] and Manjul Mehra [a]

[a] Sri Guru Ram Das Institute of Dental Sciences and Research, Sri Amritsar, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

In the field of endodontics, there has been a notable progression from direct visual observation to the use of magnification and rotary systems, replacing conventional hand files. Various magnification devices, including dental loupes, dental operating microscopes, and orascopes, are widely employed to enhance clarity and capture fine details. These devices have proven invaluable for endodontists as they allow for precise diagnosis, treatment procedures, and thorough assessment of the performed procedures. The continuous advancements in magnification techniques have contributed to improved precision and higher quality standards. Consequently, Microdentistry has established a higher level of patient care, leading to increased success rates in treatment procedures. With its evolving potential and advanced clinical implications, Microdentistry is shaping the future of endodontics.

Keywords: Magnification devices; magnification in dentistry; dental operating microscopes; micro dentistry.

**Corresponding author: Email: rashugrover@gmail.com;*

1. INTRODUCTION

Technological advancements have significantly influenced the field of dentistry, providing clinicians with tools and techniques to maximize their skills and equipment for optimal outcomes in everyday practice. Improving existing knowledge and skills is key, allowing dentists to deliver excellent results with utmost precision. In modern dentistry, having a high level of visual acuity, particularly for near vision, is crucial. One traditional method to enhance visual acuity is by virtually magnifying the area of focus [1,2]. According to Worschech et al., combining enhanced lighting with magnification can reveal distinct differences between surfaces that may appear similar in texture or color under conventional working conditions. The level of detail and clarity achieved through magnification is so remarkable that clinicians can instantly recognize opportunities for enhanced accuracy in both treatment and diagnostic procedures [3].

Throughout the years, several magnification devices have emerged as intermediary tools, bridging the gap between the microscope and the unaided eye. Traditional instruments like magnifying glasses, intraoral cameras, and endoscopes have largely been replaced by more modern and practical apparatuses in dental practice [4-7]. Among these, dental operating microscopes and loupes have become increasingly popular due to their convenience and effectiveness [8-10].

2. HISTORY

1975, Baumans article emphasizing the advantages of using an operating microscope to dentists and its potential services in endodontics was published.

1981, An introductory assertion by Apotheker was published, emphasizing the different uses of a distinct dental microscope (Dentiscope), including endodontics and teaching.

1983 Humes and Greaves briefed diverse uses of the operating microscope in general dentistry.

1984 Reuben and Apotheker tried the dental microscope (Dentiscope) in an apical surgery and suggested supplemental application in endodontics.

1986 Pecora and Adreana also utilized a microscope during the performance of 50 apicoectomies and documented a decreased incidence of postoperative.

1989 Selden and Bethlehem registered the successful non-surgical treatment of calcified canals utilizing microscopes.

1992 Carr endorsed the use of microscopes for different periodic endodontic procedures.

1995 Weller et al. emphasized the usage of surgical operating microscopes to identify and treat the canal isthmus during apical surgeries to augment the success rate [8].

Magnification is the method of amplifying the apparent size, not the material size, of something. This augmentation is calibrated by an estimated number called "magnification." A size reduction, also known as minification or de-magnification, is ascertained when this number is less than one [8].

3. THE LIMITS OF HUMAN VISION

Webster describes resolution as an optical system's capability to distinguish between two separate entities clearly. Most people who look at two points closer than 0.2 mm will see only a single point, as the resolving power of the unaided human eye is just 0.2 mm [9].

3.1 Type of Magnification System

The magnification-enhanced dentistry comprises the use of two different types of optical magnification systems:

(a) Loupes
(b) Surgical operating microscope.

Magnification loupes is the most extensively used magnification system. In this system, magnified images with stereoscopic properties, developed by convergent lens systems, are formed when two monocular microscopes with side-by-side lenses are angled to focus on an object to be magnified. A broad range of magnifications is obtainable in loupes, meandering from × 1.5 to × 10. It is invariably ideal for adjusting to the magnified vision by initially using loupes, which enable the operator to adjust to the eye training exercise and changes in hand-eye coordination. Although loupes are widely used, their notable flaw is that the eyes converge to view an image (Keplerian optics), which may result in standard eye fatigue,

and strain and sometimes even affect permanent vision change with lengthy use of ill-fitted loupes. There are three types of loupes.

4. SIMPLE LOUPES

Simple loupes consist of two positive meniscus lenses placed side by side. These lenses have two refracting surfaces, one upon entry of light and the other upon its exit. The main benefit of using simple loupes is their affordability. However, they have certain drawbacks. They are considered primitive and have limited capabilities. Moreover, they are prone to chromatic and spherical aberrations, which can distort the image of the observed object.

5. COMPOUND OR TELESCOPIC LOUPES

Magnification adjustment, the working distance (WD), and depth of field without an increase in weight or size are possible as the compound or telescopic loupes comprise multiple lenses with intervening air spaces.

6. PRISM LOUPES

Prism loupes represent a highly advanced optical solution, incorporating Pechan or Schmidt prisms that effectively extend the light path by utilizing multiple mirror reflections within the loupe. This design allows the barrel of the loupe to be compact while still achieving an extended light path. Prism loupes offer several advantages, including larger fields of view, improved magnification, longer working distances, and increased depth of field. These features make them a desirable choice for dentists seeking magnifying loupes. On the other hand, achromatic lenses, consisting of two bonded glass pieces, are designed to counteract chromatic aberration by carefully adjusting each piece's density to compensate for its adjacent piece's chromatic effects [3].

7. DIFFERENT SYSTEM OF LOUPES

1. Fill-up loupes
2. TTL loupes (Through-The-Lens)

Surgical operating microscope.

In dentistry, Galilean principles are used to design the operating microscopes. They assimilate the use of magnifying loupes in assortment with a binocular viewing system and a magnification changer such that parallel binoculars are employed to protect eye fatigue and strain. Fully coated optics and achromatic lenses with high resolution and good contrast stereoscopic vision are also employed. Coaxial fiber-optic illumination is used in Surgical Microscopes; hence, a circular spot of light parallel to the optical viewing axis is produced, which is bright, adjustable, and uniformly illuminated. Documentation, motion videography, visualization of pathologies, and management of all surgical and dental procedures can be effectively performed under unclogged vision due to its shadow-free light. Due to the beam splitter video camera attached to the microscope, the patients can directly visualize the magnified image on the screen, which helps them to counsel better [3].

8. ADVANTAGES OF MAGNIFICATION DEVICES

The usage of magnification devices in endodontics has primarily three benefits, namely,

(1) Improved visualization,
(2) Enhanced Precision, and
(3) Better Ergonomics [11-13].

9. USES OF VARIOUS LEVELS OF MAGNIFICATION

Dentistry uses different levels of magnification to address various procedures and specific needs. Here are the typical applications for different levels of magnification in dental practice:

Low magnification (3x - 8x) is suitable for tasks such as examining tooth orientation and positioning of tools like ultrasonic tips or burs. The wide field of view allows for comparisons with neighbouring anatomical landmarks. This level of magnification is commonly used with loupes, which are sufficient for straightforward cases.

Moderate magnification (8x - 16x) is commonly employed in both surgical and non-surgical endodontic procedures. It provides an acceptable field of view and depth of field, making it suitable for performing intricate procedures like perforation repair, retrieval of separated instruments, and surgical interventions requiring higher precision and accuracy.

High magnification (16x - 30x) is particularly useful for close-up examinations and observing

minute anatomical details, such as calcified canal orifices and tiny cracks. Although the field of view is smaller at this level, any slight movements can cause an immediate loss of focus. Additionally, the slight variations in color between secondary and tertiary dentin in teeth with calcific metamorphosis can be detected using high magnification.

These different levels of magnification cater to the specific requirements of each dental procedure, enabling dentists to perform their tasks with improved clarity and precision [10].

10. ERGONOMICS

The Dentist may move closer to the object and bend over to see the object, to enlarge the object in view at the dental chair. The dentists' heads and necks are bent forward to provide optimum visual conditions, due to the sensitivity and accuracy requirements, this awkward posture plays a crucial role in musculoskeletal disorders in the neck and back among Dentists [9].

Therefore, averting pain is notably essential. One of the primary objectives of ergonomics in recent decades has been to avoid discomfort. The use of magnification lenses can avert awkward posture in dentists because of their enhanced magnification and clarity of vision.

Having knowledge of primary ergonomic motion is required to comprehend the efficient workflow of the microscope.

11. THE LAWS OF ERGONOMICS [9]

Efficient workflow with an operating microscope (OM) in dentistry relies on a solid grasp of ergonomic motion fundamentals.

Ergonomic motion is broadly split into five classes of motion:

- Class I motion: moving just the fingers.
- Class II motion: moving just the fingers and wrists.
- Class III motion: movement initiating from the elbow.
- Class IV motion: movement initiating from the shoulder.
- Class V motion: a movement that implicates twisting or bending at the waist.

12. USE OF MICROSCOPE IN DENTISTRY [9]

12.1 Use in Diagnosis

Cracked tooth Syndrome: A remote area of enamel may crack or craze when a patient bites into something rigid or when subjected to an impact. Although the injury may initially initiate pain, the cushioning effect of the underlying dentin tooth structure may be sufficiently forgiving and resilient to keep the crown undamaged. Many of these superficial fractures are fairly undetectable with normal vision, but hairline cracks appear as crevasses when observed under magnification.

Soft Tissue Evaluation: - Visual and radiographic evaluations in patients, often suffering from pain and related symptoms that indicate the presence of inflammation/infection, do not always clearly indicate the problem. An infected intraosseous lesion sometimes trephines the labial plate but defies detection under traditional diagnostic procedures; however, an unobtrusive sinus tract may be identified under high magnification levels.

Gingival bleeding: Executing a little occlusal angled force at the gingival margin of the restoration usually reveals a micro-motion that is not perceptible to the eye but is apparent and skillfully detected when viewed under high power magnification.

Gingival swelling: Many a times, foreign particles, such as fruit pits, popcorn kernels, tooth chips, fingernail clippings, celery husks, fruit pits, meat, and fish bones, are often wedged and squeezed between teeth and beneath points, which results in persistent bleeding and swelling of the affected tissues making the location, identification, and removal of the impediments difficult, painful and often challenging. The naked eye and the illumination provided by a standard overhead-operating lamp are often insufficient, compromise the treatment, increase procedural difficulty, and cause unnecessary strain for both the patient as well as the doctor. When viewed under the microscope, these obstructions are recognized, captured, and easily removed.

Occlusal Caries Detection: Using an operating microscope in analyzing occlusal caries in the clinical setting is crucial to demonstrate the utility of this non-invasive procedure.

Sisodia N et al. conducted an in-vitro study to evaluate the accuracy and reproducibility of detecting incipient occlusal caries and making treatment decisions using different techniques: unenhanced visual-tactile examination, magnification with loupes, and magnification with a surgical operating microscope. The study assessed sixty extracted human posterior teeth using the ICDAS-II index and CPI-TN probe, both with and without magnification. Histopathology served as the gold standard for diagnosing caries and making treatment decisions. The findings indicated that using low-level magnification, such as loupes or a surgical operating microscope, facilitated easier and more reliable detection of incipient caries [11].

Coronal Preparation: Marginal accuracy is demanded in Restorative dentistry, mainly when aesthetics is critical to success. The loss of gingival integrity and an uncomplimentary exposure of the crown-root interface can be observed with even subtle disparities in chamfer finish, and precision is paramount to prevent adverse tissue responses and fulfill the satisfaction of the patient.

Atlas AM et al. performed an in vitro study to assess the accuracy of CAD-CAM crowns made using different techniques and compared the marginal fits of crowns fabricated with loupes during the initial preparation stage and then refined using either a microscope or loupes. The research findings demonstrated that the level of magnification employed during tooth preparation had a notable impact on the extent of marginal gaps observed in CAD-CAM crowns. When crown preparations were completed using a microscope at a higher magnification compared to loupes, utilizing fine-grit diamond rotary instruments, it led to a more accurate marginal fit with reduced gap sizes [12].

Impression Quality: Impeccable imaging of both the complete crown preparation and the untouched coronal root junction is essential for successful indirect restorative procedures. If any inaccuracies are present in the impression, they can lead to restorative misfit and subsequent marginal leakage. To prevent this, it is crucial to thoroughly examine the impression surface for imperfections, distortions, and marginal inadequacies under high magnification during the impression-taking process. This meticulous inspection eliminates the need for guesswork in the laboratory and prevents the disappointment and frustration of having to redo the restoration during a later appointment. Rejecting a flawed impression is a professional and financially prudent choice.

Assessing the underside of metal castings or ceramic-baked restorations reveals the presence of surface irregularities that may go unnoticed by the naked eye but become apparent under high magnification. These minor imperfections can disrupt the proper fitting of the restoration, affect occlusion, and, if the restoration is seated, increase the risk of marginal leakage. Moreover, the imperfect interface between the crown and the tooth can create a wedge-like effect when forced into place, potentially leading to the fracture of the prepared tooth at the contact point.

Restoration Delivery and Polish: Achieving a precise fit for a crown typically necessitates minimal adhesive and a gentle intraoral polish during the final seating. Nevertheless, even the tiniest residue of cement remaining at the margin where the crown meets the root can trigger an unfavorable reaction from the surrounding tissue. This can result in painful gingival damage, severe inflammation, and recession. Eventually, the restoration margins become exposed, and the overall aesthetic appearance is compromised. The only reliable method to ensure cleanliness at the crown-root interface is to examine the surfaces using high magnification and illumination thoroughly.

Bonded Restoration: A bonded restoration requires special attention and precision to achieve a smooth margin that does not cause irritation to the gingival tissues. As the process advances with increasingly finer burs and finishing disks, it becomes challenging to accurately assess the refined Crystal edge's surface texture. Only by meticulously fine-tuning this junction under magnification can one ensure the gingival tissues remain healthy without inflammation, bleeding, recession, or exposure of the crucial root-filling interface.

Eggmann F et al. studied the impact of magnification devices on the quality of restorative dental procedures was examined. The findings indicated that loupes with a magnification of 2.5× improved the precision of two-dimensional preparations. However, the study concluded that these loupes did not have a notable effect, whether positive or negative, on the accuracy of complex, three-dimensional cavity preparations

performed by dental students without specialized training [13].

12.2 Uses in Endodontic Therapy

Coronal Access: The pulp reacts to various factors such as age, repeated restorative procedures, injury-induced trauma, and occlusal wear by depositing layers of amorphous calcified dentin. When the pulp chamber is filled with secondary and tertiary dentin, there is a genuine risk of perforating the floor during endodontic coronal access. To avoid this, it is crucial to utilize high levels of magnification when approaching the natural floor. Proceeding without the aid of magnification increases the chances of perforation and subsequent treatment failure.

12.3 Locating Orifices

The misconception that a root contains only a single canal and exit is now widely discredited. Research has shown that the majority of roots have the potential for multiple canals and intricate intracranial connections. The success or failure of treatment depends on effectively identifying and navigating all these canal aberrations. By magnifying and adequately clearing the chamber floor, pathways leading to various canal orifices become visible. Once located and identified, these small openings become apparent, making it easier to navigate them using no. 06 or 08 stainless steel files.

Perrin P et al. assessed the effectiveness of Galilean and Keplerian loupes, both with and without integrated light, in the context of endodontic procedures. The control groups consisted of the naked eye (considered negative) and a microscope with 6× magnification (considered positive). The experimental groups included Galilean loupes with 2.5× magnification and Keplerian loupes with 4.3× magnification, with and without a coaxial light source. The study concluded that the microscope yielded significantly superior results compared to all other groups. The naked eye was found to be inadequate in achieving the necessary visual threshold at any location during the procedures [14].

Buhrley LJ et al. conducted an in vivo study in a clinical setting to investigate the effectiveness of surgical operating microscopes and dental loupes in assisting practitioners in locating the second mesiobuccal canal (MB2) of maxillary molars. The study involved 312 cases of root canal therapy performed on maxillary first and second molars by participating endodontists. The researchers concluded that the use of magnification, either through surgical operating microscopes or dental loupes, resulted in an MB2 detection rate approximately three times higher than that of the non-magnification group. They also noted that significantly fewer MB2 canals were observed when no magnification was utilized. Based on these findings, the study emphasizes the importance of using magnification to identify the MB2 canal successfully [15].

Locating and Retrieving Foreign Objects: Utilizing a high-powered microscope offers improved visibility and illumination during procedures such as simple canal re-treatment or re-treatment of a post and core-treated tooth. Additionally, it assists in retrieving fragmented or separated instruments that may have occurred during the cleaning and shaping of a canal. To locate and remove these obstacles without damaging the root, it is crucial to carefully and precisely touch the surrounding dentin with an appropriate ultrasonically powered alloy or diamond tip. Conducting this procedure without magnification increases the risk of perforation and subsequent failure.

Gencoglu N and Helvacioglu D: stated that the use of dental microscopes is crucial when dealing with the removal of fractured instruments. The enhanced vision provided by magnification and illumination allows clinicians to clearly observe the most coronal parts of broken instruments and safely extract them without causing any perforations [16].

Repairing iatrogenic and Idiopathic perforations: - Enhanced vision and illumination from a high-powered microscope is the only way to locate and repair canal periodontal ligament communications via delicate and precise intracanal access.

Endodontic surgery:- Presumably, the most considerable contribution of the microscope in endodontic therapy emerges when surgical access to an endodontic issue becomes the only resort for the extraction of the tooth. Often, the triumph of endodontic surgery gets compromised by anatomic restrictions and root aberrations (i.e., the number and location of canal exits). One must depend upon fierce illumination and an unobstructed magnified view to improving the chances of clinically detecting multiple exists and

isthmi and to parallel the retro preparation and root-end filling to the root axis.

Sajjanar A. et al. conducted a study in which the duration of endodontic treatment in primary teeth was compared with and without the use of a magnifying loupe. The study included a total of 60 cases involving deciduous molars. The participants were divided into two groups: one group consisted of 30 patients who received treatment with the aid of a magnifying loupe, while the other group comprised 30 patients who underwent treatment without the use of a magnifying loupe. The study findings indicated that the group treated with magnifying loupes required less time for the procedures compared to the group treated without the loupes [17].

Slaton CC et al. conducted an in vitro study to compare and evaluate the effectiveness of visual enhancements in identifying artificially created dentinal cracks in resected root ends. The statistical analysis revealed that the Orascope ($p = 0.02$) demonstrated significant superiority in this regard. However, using unaided/corrected vision ($p = 0.99$), loupes ($p = 0.88$), or a microscope ($p = 0.14$) did not yield notably better results than mere guessing [18].

12.4 Recent Advances in Magnification – Head Mounted Microscope

It offers a working distance ranging from 11.81 to 27.56 inches and a magnification range of 2.9× to 7.0×. The microscope is equipped with integrated light optics and an autofocus camera for enhanced convenience. It provides a field of view spanning from 1.18 to 8.82 inches and ensures shadow-free illumination during use [19].

13. CONCLUSION

The utilization of coaxial illumination and increased magnification has significantly enhanced the treatment possibilities in both surgical and non-surgical endodontics. These advancements have made previously impossible treatment modalities more reliable and predictable. Microscopes in endodontics can be likened to the discovery of X-ray radiations in dentistry over a century ago. Nowadays, it is unimaginable to have a dental office without an X-ray machine. Similarly, it can be predicted that in the near future, dentistry will extensively and universally incorporate the use of operating microscopes. The inclusion of microscope usage in the curriculum of all endodontic graduate programs further emphasizes its importance. The only limitation for operating a microscope is one's imagination, and it undoubtedly serves as a valuable tool in the pursuit of achieving excellence in endodontics.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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