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Magnification in endodontics ! Essential or Gimmick?

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Abstract:
Visualizing the oral cavity has always been a challenging task for the dentists. With the advent of magnification in the field of dentistry, which increases operator efficiency as well as the success rate. Magnification helps the user not only to see more, but to see well. Nevertheless, application of magnification in dentistry has yet to be introduced into the mainstream practice due to various influences in behavioural patterns. By conducting an extensive literature search in the PubMed database, this review paper depicts the present state of magnification devices, their applications within the endodontic practice, factors that influence their usage, the advantages, and shortcomings, as well as the significances of magnification in the field of endodontics. This review paper will serve as guide to clinicians to employ magnification in their practice for improved outcome.
Key Word*: Endodontics, lenses, magnification, optics, photonics, visual acuity, visual aids*

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I. Introduction

Dentistry is loaded with technological advancements, which help clinicians to incorporate the finest skills in the day–to-day practice for delivering the most ideal outcomes with utmost precision.[1] Visualizing the oral cavity has always been a challenging task for dentists.[2] Syngcuk Kim stated that "You can only treat what you can see". Undoubtedly, the clinician can better evaluate and treat something by visualizing it more clearly and in magnified form.

A common way to achieve a better vision is to effectively magnify the area of interest. Worschech CC et al. said that improved lighting, coupled with magnification, provides a clear distinction between surfaces that may look similar in colour or texture under traditional working conditions.[1] According to Tascheiri S et al. magnification devices are beneficial for both patient and operator, in terms of ergonomics, vision, treatment success rate, treatment times, and total costs.

In this effort, various magnification devices like surgical microscopes, endoscopes, and magnifying loupes have added advantages to the operator for better visualization. High powered magnification can be used in many aspects of general dental practice like restorative dentistry, fixed and removable prosthodontics, endodontics, pediatric dentistry, periodontics, and oral surgery.[3]

II. Methodology

An extensive literature search had been carried out by combing through the PubMed database. The MeSH keywords applied were "endodontics," "visual aid," "optics and photonics," "lenses," "surveys and questionnaires" and "visual acuity." As a result, a total of 580 articles were found. The title and the abstract of each article were then screened and only the relevant papers were retrieved in full text. From these texts, additional relevant articles were sought from the list of references. The total number of articles accumulated was 60.

III. History of Magnification In Dentistry

The use of magnification for microsurgical procedures is not a new concept. Hans and Zacharias Jansen were claimed to be the inventors of the simple and compound microscope during early 1595. The first magnifying devices to assist surgery was introduced to the field of medicine during the late 1800s.[4] Nevertheless, the first surgical microscope OPMI 1 was introduced in 1950. This instrument, which was invented and commercially marketed by Carl Zeiss Company, had a coaxial lighting system and an option for stereoscopic view. The first microscope for dentistry was introduced by Apotheker and Jako in 1978.[5] The term "Microdentistry" was coined by apothekar in the year 1980. In endodontics, microsurgery has been practised since 1986.[6]

IV. Optical Terminology

1. THE FIELD OF VIEW

As the magnification increases, the field that can be viewed decreases. It is possible to obtain loupes that magnify by as much as x6. However, in practical terms, a magnification of x2–x2.5 would enable the dental operator to see multiple quadrant areas in focus.[14] This is the magnification normally used in general dental practice and is recommended for new users. At magnifications of x3.5, the field becomes restricted to a single quadrant, while at a magnification beyond x3.5 the view becomes increasingly restricted until only a single tooth is seen. This makes high magnification unsuitable for routine operative dentistry but is helpful when undertaking specific procedures such as endodontics.

2. DEPTH OF FIELD (working range)

The depth of field refers to the ability of the lens system to focus on both near and far objects without having to change position. For normal vision, this ranges from working distance to infinity.[7] The use of magnification causes a restriction in the depth of field and, as the magnification increases, the depth of field decreases to the point that only a small object is sharply in focus and everything around is out of focus.[14] At high magnification, slight movements of the operator or patient will result in loss of focus of the area under examination, making work more difficult.

3. DECLINATION (VIEWING) ANGLE

This is the angle at which a lens is set to a horizontal reference line drawn from the superior auricular crevice to the bridge of the nose and will determine the sightline. When operating, the greater the angle to this line, the greater the neck tilt necessary to view the object.[15] It is ergonomically important to make sure that this angle is correct for the individual, to minimize strain on the neck, back and shoulders.[16]

4.WORKING DISTANCE

Working distance is measured from the eye lens location to the object in vision or is the distance between the plane of the eye and the surface being treated.[17] Working distance with slightly bent 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.[8,18,19]

5.CONVERGENCE ANGLE

Convergence angle is the pivotal angle aligning the two oculars, such that they are pointing at an 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.[9]

6.INTERPUPILLARY DISTANCE (IPD)

IPD depends on the position of the eyes of each individual and is a key adjustment that allows long-term, routine use of magnification devices. The ideal setting, as with binoculars, is to create a single image with a slightly oval-shaped viewing area.[20]

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 brightness of the light, ease of focusing and directing the light within the field of view of the magnifiers, and ease of transport between surgeries.[10]

V. Types Of Magnification Devices In Dentistry

The modern-day dentist has numerous magnification systems to choose from. These magnifying systems range from simple loupes to compound prism telescopic loupes and the vast variety of surgical microscopes. Each magnification system has its advantages and also its limitations. [4]

LOUPES

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.

- **Based on optical construction**

• Simple loupes
• Compound loupes

• Galilean loupes
• Prism loupes.

- **Based on design**

•Flip-up loupes
•Through the lens loupes (TTL)

BASED ON OPTICAL CONSTRUCTION

- **SIMPLE LOUPES**

Simple loupes consist of a pair of single, positive, side- by- side meniscus lenses. Each lens has two refracting surfaces. The first refraction occurs when light enters the lens, and the other refraction happens when the light leaves. The magnification of simple loupes can be increased only by enhancing the lens diameter or increasing the lens thickness. The size and weight are the limitations of these devices, so they do not have any practical applications in dentistry.[21]

- **COMPOUND LOUPES**

Compound loupes have an array of convergent multiple lenses. There are air spaces in between these lenses which gives an additional refracting power, magnification, working distance, and depth of field. Such loupes can be easily adjusted as per the clinical requirements by lengthening or shortening the distance between the lenses. Compound lenses can be achromatic, and this feature is to be given importance while selecting a dental loupe. These achromatic lenses are efficient in producing a colour perfect image.

- **GALILEAN LOUPES**

These loupes are cheap and are simple to operate while compared to other compound loupes. These loupes consist of only 2 or 3 lenses which make them light in weight and also inexpensive. Their only disadvantages are limited magnification (2.5- or 3.5- fold) and a blurry peripheral border of the visual field.[11]

- **PRISM LOUPES (OR WIDE- FIELD LOUPES)**

As their name itself suggest, these loupes consist of prisms that are used to refract light rays. These prisms are used to lengthen the light path through a series of switchback mirrors positioned between lenses. This system hence provides better magnification, wider depths of field. This also ensures the users have long working distances and if compared with other loops they have larger fields of view. So these loupes are the optically most advanced type of magnification instrument in the market at present. The ranges of magnification of these loupes are around 1.5x to 6x. [11]

BASED ON DESIGN

•FLIP-UP LOUPES

The telescope is mounted further away from the eyes whereas its scope is mounted in front of the lens in a hinge mechanism, which provides a narrower field of vision. It has a better declination angle (at which the eyes look down toward the area being worked on) which can be changed according to the user. The head position becomes neutral if the declination angle is steeper. Flip-up loupes are heavier than TTL loupes.[22]

•THROUGH THE LENS LOUPES (TTL)

TTL loupes provide comfort and a wider field of vision as they are positioned closer to the eyes**.** The scope is mounted on the lens. It is designed specifically for an individual and the angle of declination is set in the factory where they are made. Change in eye prescription requires scope to be demounted to replace the glass. It is lighter and expensive than flip-up loupes.[12]

VI. Dental Operating Microscope

An The dental operating microscope not only provides better magnification from 3x up to 30x but also better illumination. The microscope through its enhanced vision has greatly contributed to improved surgical as well as conventional treatment.[24]The range of working positions with microscope usually from 9 o'clock to the 12 o'clock position.[25]

The operating microscope consists of three basic components-

1)**The supporting structure** 2) **The body of microscope,** 3)**The Light Source**

SUPPORTING STRUCTURE

The microscope must be stable while in operation, yet remain manoeuvrable with ease and precision, particularly when used at high power. The supporting structure can be mounted on the floor, ceiling, or wall.[23]

THE BODY OF THE MICROSCOPE

It is the most crucial element and consists of eyepieces, binoculars, magnification change factor, and the objective lens.[23]

a. Eyepiece: Magnifying the image is the most important function of the operating microscope. The power of the eyepiece determines magnification. Eyepieces are usually available in powers of 10x, 12.5x, 16x, and 20x. To adjust the accommodation of the lens of the eyes, diopter settings should range from -5 to +5.[23]

b. Binocular: They are available with straight, inclined or inclinable tubes with provision to hold the eyepieces.
c. Magnification changer: It is situated within the head of the microscope and is available as a 3, 5 or 6 step manual changer, or a power zoom changer.[26]
d. Objective lens: It is the final optical element, and its focal length determines the working distance between the microscope and the surgical field. The focal length ranges from 100 mm to 400 mm. A 200 mm focal length permits approximately 20 cm of working distance, which is generally appropriate for utilization in endodontic procedures. [27]

THE LIGHT SOURCE:

It is one of the key features and responsible for working in operative fields that are small and deep like the root canal.[28] Three light source systems are commonly available:1)halogen light, 2)xenon light, 3)LED light

HALOGEN LIGHT

Halogen lighting was the first dental microscope light source introduced. It is still available for standard applications and basic microscopes and displays a yellowish hue. [29]

XENON LIGHT

Xenon and the more recent light sources were developed to deploy better illumination to the operating field. Xenon light sources appear almost as natural as daylight while providing the highest light intensity.[30]

LED LIGHT

LED light sources are similar to xenon in colour temperature and appear close to natural daylight. In comparison to xenon and halogen, the heat emission from LED radiates from the back of the light source, resulting in a greatly reduced temperature surrounding the microscope. [31,32,33]

All three light sources differ from each other in light intensity, peak wavelengths, colour temperature, heat emission, and lifetime.[34]

VII. Optical Principles Of Magnification Devices

An An increase in magnification decreases the focal depth. Wearing loupes, especially at magnifications higher than ×4, requires the practitioner to stay in a narrow range from the object to stay in focus. In contrast, even at high magnifications, a microscope remains stable and the practitioner can work in an upright and ergonomically non-stressful position.[35] Moreover, microscope use reduces strain on eye muscles, fatigue, and soreness compared to loupes.

Through a microscope the light reaching the left and right eyes appears to be essentially parallel, achieving the effect of far distance observation and avoiding short accommodation stress as with the naked eye.[36] Binoculars of loupes and thus the viewing direction are convergent, resulting in similar eye strain. In addition, microscopes provide imaging virtually free of shadows, allowing excellent image quality for clinical operations and documentation.[37]

VIII. The Laws Of Ergonomics

An An understanding of efficient workflow using an OM entails knowledge of the basics of ergonomic motion.[38] Ergonomic motion is divided into 5 classes of motion:

Class I motion: Moving only the fingers.
Class II motion: Moving only the fingers and wrist**.**
Class III motion: Movements originating from the elbow.
Class IV motion: Movement originating from the shoulder.
Class V motion: Movement that involves twisting or bending at the waist.[39-42]

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IX. Uses Of Magnification

a) **Examination, diagnosis, and treatment planning:**

Demineralization around the grooves and tiny amounts of flaking of darkened carious tooth structure within the crevices of these grooves can be appreciated with magnification, which can be a vital element in diagnosis and deciding the treatment plan.[43,44]

b) **Diagnosis of cracked teeth :**

Cracks in teeth or restorations, craze lines, wear facets, cracks at slightly elevated marginal ridges can be appreciated under magnification.[45]

c) **Better visualization of the pulp chamber, canal orifices :**

Magnification aids in Better visualization of anatomical landmarks, within the pulp chamber—including the sides, overhanging remnants of the pulp chamber roof, initial perforations into the pulp, dentinal map, canal orifices and to differentiate between the pulp horns and the main body of pulp within the chamber.[46]

d) **Cleaning and shaping :**

The improved ability to see specific canals allows endodontists to manoeuvre files into canal openings with greater efficiency. To determine if all canals are accessed and instrumented properly when a direct view might be difficult without removing excessive
amounts of coronal tooth structure.[47]

e) **Identifying obscure anatomy** :

Anatomical variations are not as rare or exotic as is frequently assumed. The introduction of the dental microscope and the associated ability to inspect the root canals have shown better results in detecting the hidden canals .[48]

f) **Identification and removal 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 readily with the help of a dental operating microscope and ultrasonics tip.[49] An ultrasonic tapered and active tip Start-X™ #3 (Dentsply Maillefer) was introduced to remove the calcific obstruction. The entire mass could be dislodged from the walls of the pulp chamber and its underlying attachment.[50-53]

g) **Effective Obturation:**

Proper illumination and magnification aids to visualize the space in the root canal system. During obturation, this helps us to achieve the ideal apical seal. Root canal sealers can be better placed under magnification, such a uniform coating of root canal walls can be achieved.[54] While performing sectional obturation and using thermoplasticized guttapercha, use of DOM is a very helpful aid.[55]

h) **Management of open apex :**

The main goal of this procedure is to control the bacterial infection and establish a suitable environment for the induction of calcified tissue into the apical area. Manipulation of modern apexification therapies for special treatment techniques and materials has been facilitated significantly under a dental microscope. The dental operating microscope has aided tremendous improvements in visual acuity of the open apex and hence has made it possible to provide proper sealing using an apical barrier. The use of an operating microscope allows better control of the placement of the MTA apical plug.[56-58]

i) **Retrieval of Fractured Posts and Instruments:**

Due to enhanced vision with magnification and illumination, the Dental operating microscope allows to detect of the proper location of the fractured post and broken instruments and to remove them minimal loss of healthy tooth structure.[59,60]

j) **Microsurgical Endodontics:**

In the early 90's microscopic approach in surgical endodontics with the applicability of retro mirrors and resected apical root segment atraumatically with more moderate resection angle. He concluded that the microsurgical approach leads to less trauma and faster healing.[61]

X. Advantages Of Microscope

a) Higher magnification
b) Better illumination
c) Superior optical properties
d) Galilean optics reduces the need to have the eyes converge to focus and thereby reduces eye strain and fatigue.[62]

XI. Disadvantages Of Microscope

a) Occupies a lot of space.
b) Bulky instrument.
c) Training regarding its parts and usage is a must before surgery.
d) Expensive.
e) Requires high maintenance.[63]

IMAGES :

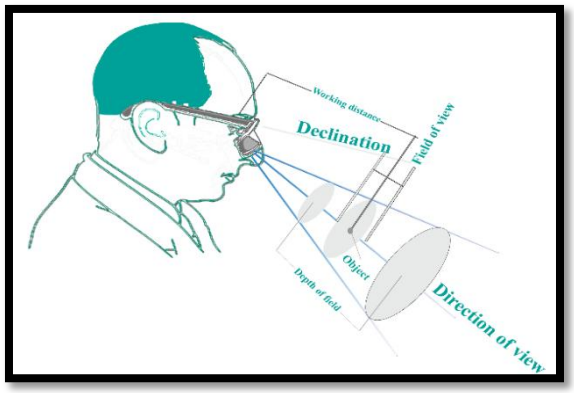

Figure 1 PRINCIPAL OPTICAL FEATURES OF LOUPE

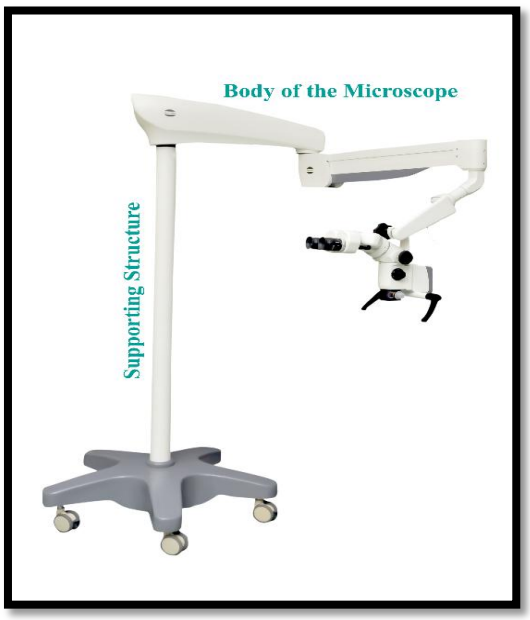

Figure 1 PARTS OF MICROSCOPE

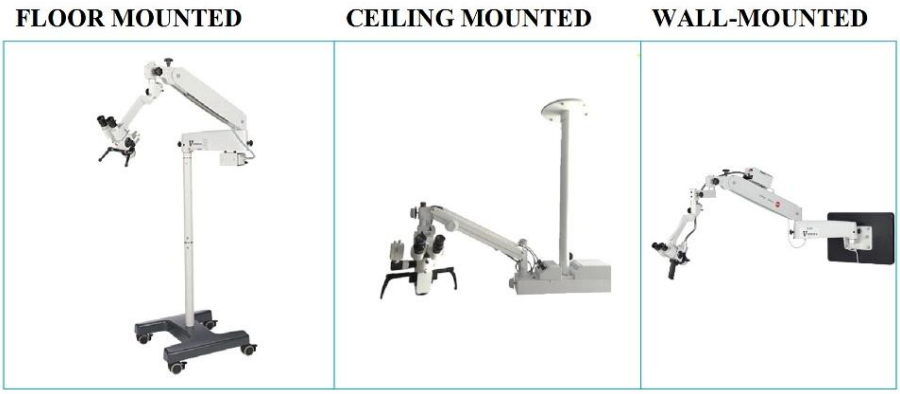

Figure 2 TYPES OF SUPPORTING STRUCTURE

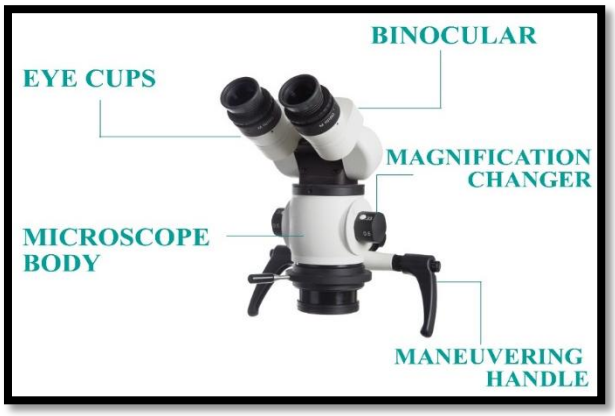

Figure 3 BODY OF THE MICROSCOPE

Figure 4 EYE PIECE

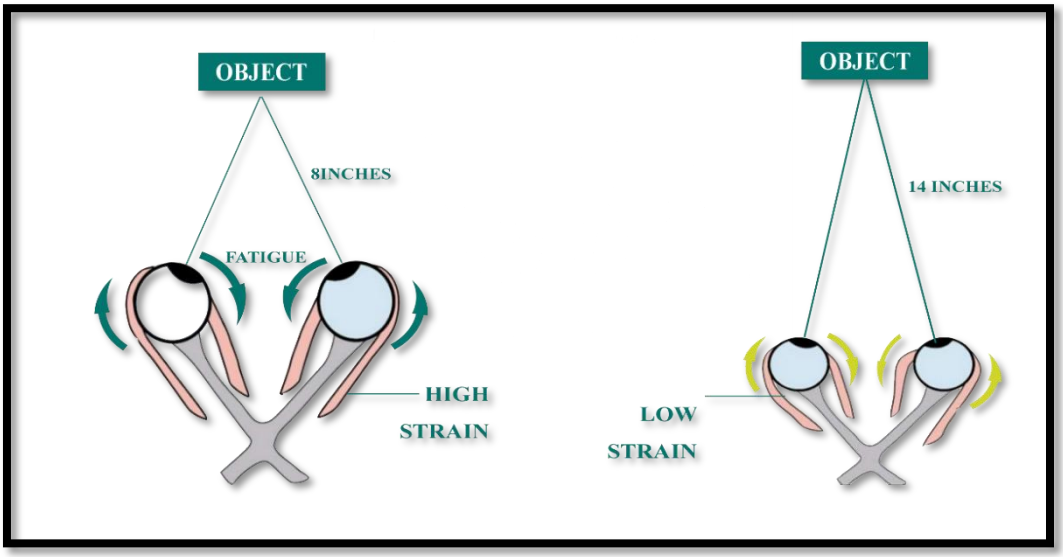

FIGURE 5 OCCULAR ANGLES IN LOUPES AND MICROSCOPE EXPLAINING THE STRAIN PRODUCED

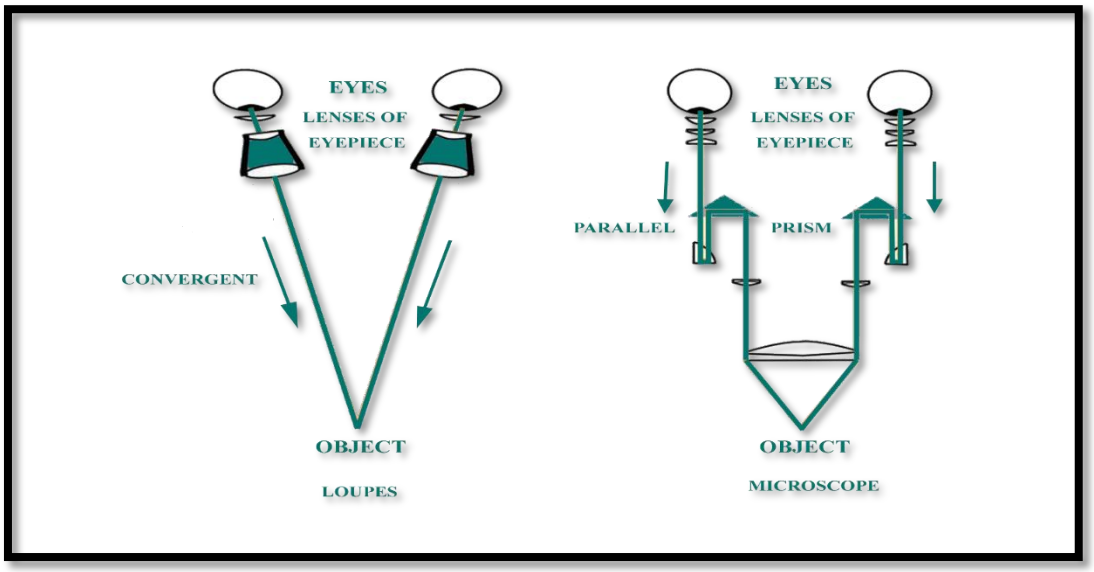

FIGURE 6 COMPARISON OF OCULAR ANGLES AND VIEWING DIRECTIONS OF LOUPES AND MICROSCOPE

Table no 1 : ***Advantages And Disadvantages Of Loupes***

	Single Lens Loupes	**Galileian Lens Loupes**	**Keplerian loupes**
Advantages	Most inexpensive system	Economical Simple to operate	Provide broader fields of view, wider depths of field and longer working distance
Disadvantage	Plastic lenses used are not always optically correct.	Blurry peripheral border of the visual field because of their limited magnification	Heavier and more costly

Table no 2 : ***Comparison between Xenon ,Halogen ,LED light source***

	Xenon	**LED**	**HALOGEN**
Light spectrum range	Homogenous spectrum from 400 to 700 nm	The green part of the emission spectrum under-represented Peaks: 450 nm and 550 nm	Peak: 600–700 nm
Appearance	Like daylight	Comparable to xenon	Yellowish hue
Colour temperature	5500 K	5700 K	3300 K
Intensity at 250 mm focal distance	200 000 lux	85 000 lux	85 000 lux
Average lifetime	500 h	70 000 h	50 h

XII. Conclusion

Microscope Enhanced Dentistry is a wonderful revolution and is the direction in which dentistry is moving. In the end, excellent visual information can help the doctor to create more precise, more healthful, and more esthetically pleasing dentistry. It provides better ergonomics for a longer duration and with increased precision. Magnified dentistry is definitely the future for predictable and ergonomic dentistry .

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