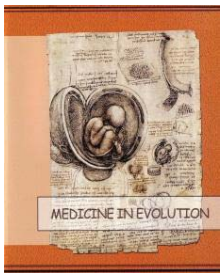
Loupes - the first step towards an enlarged image and optimal visibility in dentistry



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Abstract

Dentistry is a field that involves working on small structures, difficult to access and visualize. In order to perceive the details of finesse, it is necessary to enlarge the image with the help of specially designed systems, of which a first option are the loupes. The dentist who engages in the search for loupes suitable for his practical needs must know a specific optical terminology and deepen a series of technical details that characterize the different types of loupes on the market. Each of them has different degrees of magnification, possibilities of adaptation during work, different advantages and optical disadvantages, which can make the choice difficult. This article summarizes this information. In conclusion, it follows that currently available loupes are complex optical systems that can be of great help to the dentist, provided they are thoroughly known and assimilate a correct way of use.

Keywords: magnification, Galilean system, Keplerian system.

INTRODUCTION

Dentistry is about working on small tissue structures, their correct visual perception implies pushing the operator's visual capacity close to its natural limit. In general, increasing the size of the object image is useful for perceiving fine details. Therefore, in order to increase working precision and to obtain high quality practice, optical magnification systems are necessary [1]. The size of the image can be enlarged either by bringing the object closer to the eye or through the use of optical magnification systems. The use of optical magnification systems in dentistry enables the increase of the working distance and allows the external ocular muscles to remain relaxed and the physician's posture not to be affected [1].

The different specialties of dentistry have different challenges regarding technical execution, but the condition of optimal visibility remains generally valid. Several specialties of dentistry, which require increasing accuracy and precision of execution are the beneficiaries of the optical magnification systems. Thus, special challenges regarding visibility can be encountered in endodontics, prosthetics, periodontics, orthodontics and implantology.

Magnification systems enable the achievement of high levels of performance, otherwise impossible to achieve. To this matter dental loupes bring an important contribution, while the operating microscope excels. The use of magnification systems opens an era of "micro" interventions: micro-dentistry, micro-endodontics, micro-surgery, etc. Special endodontic interventions (perforation detection, location and removal of fractured instruments, etc.) or microsurgery are just a few convincing examples [1]. Modern endodontics also benefits from other tools designed for improving visibility - the endoscope and the orascope [2].

Aim and objectives

Ensuring optimal visibility of the operating field is a major problem in dentistry and a challenge from the ergonomic perspective. How to obtain optimal visibility, how to maintain it throughout the medical procedure and what are the limitations of this desideratum in current practice are questions that naturally arise to the dentists. The doctor's perception of the dimensions of the operating field, the degree of fidelity of the perception and the level of detail noticed in current practice influence the quality of the medical act and of the entire treatment in general.

The benefits of using magnification

The main benefits of using magnifying systems are:

a. improving visibility on fine details of the operating field;

b. compensating for presbyopia;

c. ensuring a correct posture of the operator.

a. Magnifying the image helps the practitioner not only to see more, but also to see better, to receive visual information that helps him diagnose and treat. With the naked eye, most practitioners cannot see an edge, a limit below 0.2 mm. At this level and below it there are details that must be perceived for accurate therapeutic interventions [3]. One can say that magnifying the image in dentistry brings us closer to the reality we want to see [4]. The human eye offers a magnification of 0.068 cm, considered a 1x magnification. Current magnifying systems offer a magnification of 2.5 x to 40 x. Magnifying the image with specific tools involves enlarging the image on the retina [2].

b. Visual acuity implies the ability to perceive details and to accomplish accommodation; it is affected when presbyopia is installed. Visual acuity is determined by the threshold to which fine details of an object are perceived, the perception being dependent on the angle of view. Details perception implies a linear dimension- it is the distance to which 2 visual elements are perceived separately. This value is directly dependent to the distance at

which the object is placed (the smaller the distance, the larger the image of the object) and the light intensity. Eye accommodation is the ability of the eyes to change their optical characteristics in order to focus on an object [5].

Presbyopia is characterized by the progressive loss of ocular accommodation due to sclerosis of the ocular lens, increased sensitivity to brightness and decreased sensitivity when perceiving contrasts. It occurs near the age of 40, but it is often discovered and corrected a few years later, when it limits daily activity.

Due to aging, it is recommended that dentists perform a periodic eye examination every 2 years by age of 50 and annually after this age. Working distance increases with age and with the appearance of presbyopia, but the use of corrective systems (glasses and loupes) brings the working distance back to a level convenient for the doctor's posture [6].

c. The ergonomic benefits of magnification systems vary depending on their type and the correctness of their use. Choosing the right magnification system, adjusting it properly and going through a period of learning and adaptation will allow the doctor to adopt a correct working posture and to avoid wear out of the neck and back. Dentists should be aware of how the use of magnification systems affects them on short or long term. For some doctors, the adjustment process can be quite difficult, but those who have managed to introduce the use of magnification systems into current practice appreciate the improved visibility and the benefits of correct posture [6].

Improved visibility also leads to a shorter working time, another significant ergonomic advantage [7].

There are two main types of optical magnification systems used in practice: loupes and operating microscope [1,8]. This article focuses on dental loupes and does not elaborate the operating microscope.

Loupes are an ideal first step in working with magnification systems because they allow the operator to adapt his vision and adjust to the changes in hand-eye coordination relatively easily. They are also the most frequently used magnification system in dentistry [2,8]. The efficient use of dental loupes requires a good knowledge of their characteristics, a correct type choice and the completion of the learning steps through which one reaches a good hand-eye coordination when using these systems [8].

Optical terminology

A specific optical terminology is used in literature to describe the components of eyesight and optical systems that provide various degrees of image magnification. I consider their general presentation necessary in order to understand the features, advantages and disadvantages of different types of loupes.

1. The working distance (WD) is the distance measured from the eye lens to the object being looked at or, in other words, from the eye-plane to the surface to be looked at. Dentists often suffer while trying to shorten the working distance in order to see better, generating unwanted effects on the back, neck or eyes. The ideal working distance is between 30-45 cm, varying with the height of the operator and the size of the body segments; taking these coordinates into account the doctor can obtain both a correct posture and eye comfort. [1,8]. Other authors provide lower values, averaging between 28-38 cm for the working distance [2].

2. The depth of field (DOF or working range-WD) is given by the interval in which the viewed object remains well focused or the interval in which the viewed object is clearly perceived at an appropriate working distance. For a normal vision, the depth of field of vision extends from the working distance to infinity [1,8].

The depth of the visual field determines how far the practitioner can approach or move away by moving his head from the operating field and still clearly perceiving the operating field. For example, for a depth of field of vision of 20 cm the practitioner can move

away or closer 10 cm and the object of sight is still clearly perceived (focused). Thus, a proper depth of field of vision reduces operator fatigue, it averages ideally around 10 cm [3].

Normally, the position of the eyes and the posture of the body have slight constant variations. The use of loupes modifies this geometry, the body posture and the activity of the extra ocular muscles being influenced to a greater or lesser extent, depending on the characteristics of the loupes. Regardless of the type of loupes and the manufacturer, the higher the magnification offered, the lower the depth of field of vision, possible to a point where only a small object remains well focused and the surrounding elements are not well perceived. At high magnification any movement of the patient or of the operator leads to the loss of image focus, which makes working quite difficult [1,6].

3. The convergence angle is the angle of alignment of the two oculars so that the axes meet at equal distances and identical angles. For a certain working distance the convergence angle varies with the pupillary distance [1,8].

4. The field of view (or width of field) is the size or the extent of the perceived area when loupes are used [1,8]. The higher the magnification, the smaller the field of view [1]. For example, the visual field may be reduced to the perception of a single tooth or wider to the perception of a group of teeth. A wider field of view is better when discussing instrument handling and reducing eye fatigue [3]. At a magnification of 2-2.5 x the operator can perceive several quadrants, so this is a degree of magnification frequently used in general practice and often used by beginners. At a magnification of 3.5 x the visual field is reduced to a single quadrant, and at a magnification greater than 3.5 x a single tooth can be perceived [6].

5. The pupillary distance (IPD) is a value that depends on the natural position of the eyes (the distance in millimeters between the pupils of the two eyes) and is the key to adjusting the magnification system used. It varies with each person, and it is a very important reference element for learning and correctly long-term using magnification systems [1,8]. Loupes that allow the adjustment of the pupillary distance can be used by more operators. The ideal adjustment of the oculars allows the creation of a single image, with a slightly oval shape [1].

6. The viewing angle is given by the position of the two oculars of the optical system, angled to the horizontal so as to allow the operator to adopt a comfortable working position. The smaller the angle of view, the greater the inclination of the head of the operator necessary to perceive the object [1,8]. Therefore, loupes designed for dentists must have a greater angulations than those for other workers. The viewing angle must be adjusted and has a specific value for each user [1].

7. The declination angle is the angle to which the loupes are positioned in relation to a reference line - the natural line of sight (drawn from the upper edge of the ear to the base of the nose). The greater the angle, the more bending of the head will be necessary in order to see. From an ergonomic point of view, it is important to evaluate and set this angle correctly for each operator [6].

8. The resolution is about the clarity of the given image, it includes the ability to identify small, close visual elements and it depends on the quality of the optical system used and on the accuracy of the lenses. Unfortunately, the only way to evaluate it is by using and comparing different optical systems [3,7].

Types of loupes

Depending on the number of lenses, the loupes can be simple loupes (single lens) or optical systems with multiple lenses (compound loupes): the Galilean optical system and the prismatic optical system (Keplerian).

a. Simple loupes are represented by a pair of positive simple lenses (meniscus lenses side-by-side), these are the simplest and cheapest loupes [1,5,7,8]. The main disadvantage of simple loupes is the limited magnification capacity [7, 8]. With simple loupes, image

magnification and clarity (focus) are obtained for a specific working distance, which can affect the doctor's posture, generating the installation of tension in the neck and back [1,2]. In addition, for a higher degree of magnification the required working distance decreases, which also leads to ergonomic problems (magnification over 2 x) [5,8].

Thus, in addition to the limited magnification capacity, other disadvantages of simple loupes add up: maintaining a fixed working distance, the increased risk of postural damage as well as spherical and chromatic alterations that distort the image, especially at its periphery [7,8].

Simple loupes can be presented as lenses mounted in spectacle frames or can be foldable, mounted on spectacle frames or on a device that sits on the head.

b. Compound loupes are represented by multi-lens or telescopic systems, with air between lenses, which allow the adjustment of magnification, working distance and depth of field without a major increase in size or weight [1,2,7,8]. They come in two types: the Galilean system and the prismatic-Keplerian system.

Galilean loupes are most often used in dentistry, and they are a combination of convex and concave lenses and have a typical conical shape. When compared to simple loupes, the system allows greater magnification, better resolution, adjustable working distance and greater depth of field. It is a relatively easy and inexpensive system [2]. The magnification offered is between 2 x and 4.5 x, but a maximum of 2.5 x magnification is usually used. A magnification greater than 2.5 x, comes with significant problems with the system's size and weight, image resolution, difficulty in focusing the image, and image distortion at the periphery of the field of view (spherical aberrations). All Galilean systems produce a peripheral halo that can be disturbing for the operator [2,5,7].

In conclusion, we can say that the Galilean system is a low magnification system, going generally up to 2.5 x, cheap, with several disadvantages, but easier to assimilate by the operator. It is useful in current universal practice, including for sanitation [3]. These loupes can be custom made for an operator [7]. Figure 1 illustrates a Galilean system.

Prismatic loupes or Keplerian loupes are the most advanced magnifiers. They represent a complex optical system, made up of lenses and prisms (5 lenses and 2 prisms) that allow the adjustment of the working distance and the degree of magnification. The prisms offer the light a long path through a series of reflections so that the final weight of the device is as low as possible. Prismatic loupes have a characteristic cylindrical shape [2,5].Their degree of magnification ranges between 1.5 x-6 x, but the magnification used in dentistry is generally over 3.5 x, limited so as to decrease the effect of the depth of field of vision reduction that comes with the increase of magnification. They offer a high magnification, a clear image of the entire field of view, a wider field of view, a greater depth of field and a greater working distance. Thus, this system is indicated for the perception of very fine details (eg. in endodontics). Prismatic loupes are the most advanced in terms of optical performance, but they are heavier and more expensive [2,3,5,6,8]. These systems can be custom made for the user [7]. Figure 2 illustrates a Keplerian (prismatic) system.

Figure 1. Techne-RX-Galilean, UNIVET

Figure 2. Techne-RX-Prismatic, UNIVET

In relation to the positioning of the optical system, the compound loupes (Galilean or Keplerian system) can be: flip-up loupes or through-the-lens (TTL) loupes.

a. Flip-up loupes have the optical system attached to a movable arm, mounted on the frame of the glasses and it is adjusted manually at every use. When not needed, the mobile element can be easily removed (eg. in order to communicate with the patient) and then reapplied. This option is advantageous due to the lower price and to the fact that it allows changes imposed by the change of the prescription from the ophthalmologist- if so, the necessary correction being included in the glasses. The disadvantages are given by the higher volume and weight of the system (compared to the TTL type) and the smaller size of the field of view offered, they are also more exposed to contamination due to frequent handling, and repeated movements can cause changes in the position of the mobile element which includes the loupes [3,6,7]. Figure 3 illustrates the flip-up loupes.

Figure 3. Air-X-Prismatic, UNIVET

b. Through-the-lens (TTL) loupes have the optical system mounted directly on the lenses of the glasses, according to operator-related specifications (eg. pupillary distance). The advantages are: lower weight, larger field of view (the optical system is closer to the eyes) and they ensure correct positioning. The disadvantages of the system are: they are used only by the practitioner for whom they were ordered, the significantly higher price and the fact that they must be completely removed when they are not needed (eg. for communication with the patient). The corrective indications from the ophthalmologist are included mainly in the optical system, not so much in the glasses, so that the changes of the medical-ophthalmological data of the operator (ophthalmological prescription) imply modifications of the optical system operated by the manufacturer. Any small error can cause eye strain when the system is used for more than 30 minutes [3,6,7]. Figure 1 and figure 2 illustrate TTL loupes.

Choice of loupes and personalization

Numerous types of dental loupes have appeared on the market from different manufacturers, each with a series of technical specifications which makes a good choice a difficult task. Choosing dental loupes involves a careful evaluation and weighing of the various optical features (magnification, image clarity, width of field, depth of field, etc.) and ergonomic aspects that derive from their use. It should be emphasized that a larger image does not necessarily mean better visibility. Usually, a clear and sufficiently enlarged image provided by high-performance optical systems implies a higher weight, a lower depth of field and a smaller field of view. This relationship is generated by the laws of physics and cannot be avoided. The best dental loupes offer in addition to magnification a good resolution, an ideal field of view and an appropriate depth of field [5,7]. The choice also depends on the frequently performed daily procedures and their degree of finesse [3].

The individualized dental loupes, custom made, must take into account the indications of the ophthalmologist and the essential data, such as the pupillary distance, must be correctly measured. Therefore, in order to choose the most suitable optical systems, it is

necessary that the dentist does a careful documentation, consults the ophthalmologist and asks for recommendation from the specialist representing the manufacturing company [7].

Ergonomic aspects of using dental loupes

There are many studies that draw attention to the medical problems of the dentists in relation to their profession, problems that tend to worsen in time. Most dentists claim at some point poor visibility in relation to decreased visual acuity and also a number of musculoskeletal problems due to poor posture. Musculoskeletal damage occurs mainly in the neck and lumbar region [9]. Insufficient visibility and illumination often lead to excessive bending of the head in order to approach the operating field. With the correct use of the dental loupes, the dentist can benefit from optimal visibility by the enlargement of the image at an increased working distance, which is ergonomically convenient. The dental loupes allow a safe and comfortable low head flexion of up to 20 degrees [1]. The weight of the optical system (higher for prismatic magnifiers and for the flip-up type) is added to the muscular stress of the neck and back of the head and it increases the risk of musculoskeletal damage.

If accommodating with the dental loupes lasts a week or more, this is a sign that the operator is making a significant unnatural effort to adjust considering that the dental loupes should serve him and make his work easier. In such conditions which require significant effort to accommodate the doctor becomes extremely vulnerable to eye strain and pain in the neck and back. Enlarging the image certainly brings benefits to the patient by increasing the quality of the operation, but it must also bring benefits to the comfort and health of the doctor [9].

There is no evidence so far that prolonged use of dental loupes is harmful to the eye. However, special attention should be paid to those who suffer from convergence insufficiency. When not detected before wearing dental loupes, it can occur as a reduction of the field of vision. After prolonged use of dental loupes a pathology quite difficult to treat may occur, its symptoms being headaches and blurred vision. This risk can be avoided by consulting the ophthalmologist before purchasing and using dental loupes and by ending the use of the optical system when symptoms occur [6].

CONCLUSIONS

An enlarged image of the operating field, especially when the details to be viewed are extremely fine, is a justified desire of general practitioners or specialists. Detailed knowledge of the different types of dental loupes, with their limitations, optical advantages and disadvantages, as well as the understanding of the ergonomics implications of their use can lead the doctor to make a choice in accordance to his needs. Careful documentation is necessary on this work tool that is interposed between the doctor's eyes and the work field for the expected result to become accessible and satisfying.

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