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Review

# GALILEAN AND KEPLERIAN LOUPE SYSTEMS IN DENTAL MEDICINE

Iris Urlić[1], Josip Pavan[1], Dubravka Negovetić Vranić[2], Željko Verzak[2] and Zoran Karlović[3]

[1]Department of Ophthalmology, Clinical Hospital Dubrava, Av.Gojka Šuška 6, Zagreb, Croatia;
[2]Department of Pediatric and Preventive Dentistry, School of Dental Medicine, University of Zagreb, Croatia;
[3]Department of Endodontics and Restorative Dentistry, School of Dental Medicine, University of Zagreb, Croatia

SUMMARY – Our ability to perform visual tasks depends on how our eyes perceive the details of the task. Magnification loupes rely on light refraction through lenses. The Keplerian telescope has a converging lens eyepiece and the Galilean telescope a diverging lens eyepiece. The size of the image when viewing through the lenses depends on the level of magnification. Dental loupes are available with magnification powers from around 2.5x and some go up to even 6.0x. Telescope glasses are made with optical barrels, carrier lenses and carrier frames. Important quality factors for the lenses are resolution, field of view, depth of field, optical aperture and weight of the telescope system.

Dental loupes with magnification powers ranging from 3.5x to 5.0x are ideal for dental procedures requiring high levels of precision and accuracy. The loupes make it easier to navigate the oral cavity clearly and examine every essential part of the gums and teeth during dental check up. By providing a magnified view of the operating field, clinical works become easier, more efficient and safer.

Keywords: *loupes in dentistry*; *ergoophthalmology*; *Galilean and Keplerian optical system*

## Introduction

Optimal working conditions in the dental office include the dentist's work in an upright sitting position in a dental chair with the full surface of the feet touching the ground, the dentist's knees located below and the elbows at the level of the patient's jaw. The illumination of the space and work area is an important contribution to ergonomic working conditions, as well as visual requirements[1]. It is recommended that the operating light be parallel or up to 15° from the line of sight of the operator and that it is discreet and positioned behind the operator's or dentist's head. The dental office must be lit by a natural and artificial light source from 250 to 500 lux meters. The advantage of sunlight is its diffusion and the fact that it is richer in light radiation of short waves, blue and purple, than artificial lighting. The work area should be illuminated with a 60 W operating lamp. The dentist must have a

Correspondence to: *Iris Urlic*
Department of Ophthalmology, Clinical Hospital Dubrava, Av. Gojka Šuška 6, 10000 Zagreb, Croatia
iris.urlic@gmail.com; Tel.: +385-91-4874-700

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maximum head deflection of up to 25° forward, which achieves an ergonomic working posture. A complete optimization of working conditions is achieved by using magnifying aids with a correction of the refractive error and correcting the weakening of eye accommodation[2].

## Fundamentals of magnification in dental medicine

Optics is a branch of physics that studies the properties of light and its interaction with matter. Light is part of the spectrum of electromagnetic radiation the human eye sees; infrared and ultraviolet radiation. Applied optics deals with the construction and optimization of optical elements, such as lenses, mirrors, prisms, eyepieces, microscopes and telescopes[3]. Optical magnification is the process of enlarging the image of an object, but not the physical shape of the object. Magnification is used in detailing objects, increasing resolution, using microscopes, and in printed and digital techniques. Natural magnification is achieved by moving the object as close to the eyes as the accommodation allows and enlarging the image of the object that is created on the retina as much as possible. Optical magnifications can be linear or angular. Linear magnification is defined as the ratio of the height of an image to the height of an object. Angular magnification tells us how much larger an object looks to us compared to when we look at it with the naked eye. It is calculated by dividing the focal length of the lens and eyepiece[4]. Thus, if we have a telescope with a focal length of 1250 mm and the eyepiece has a focal length of 10 mm, the magnification will be 125x. The maximum magnification that a telescope can give is calculated by multiplying the lens diameter in mm by two. Magnification aids increase productivity and the degree of quality of dental work. Working without magnifying aids conditions the position of the head and neck in an unbalanced forward position and can be the cause of an occupational disease: tension neck syndrome. Symptoms of tension neck syndrome include headaches, chronic pain in the neck, shoulders and interscapular regions with the propagation of pain in the hands. Cervical degeneration of the spinal discs and spondylosis can also result in prolonged irregular head and neck position during dental work[5].

## Magnification aids in dental medicine

Three basic types of magnification are used in dental practices: LCD screens, surgical operating microscopes and magnifying glasses or telescopes[6]. Ergonomic use of magnifications implies an adequate selection, adjustment, period of accommodation and adaptation to the optical aid, as well as noticing the benefits of magnification. The use of LCD screens and operating microscopes allows for a neutral position of the head (ear-front-shoulders). Well-designed magnifiers allow a working posture with the head tilted forward by less than 25° and thus improve musculoskeletal support and reduce the possibility of tension neck syndrome. Magnification with magnifying glasses is achieved from 2.0x to 5.0x. For dental assistants, it is recommended to use magnifying glasses 2.0-2.5x, for general dentists 2.5-3.5x and for endodontics/periodontology 3.5-4.5x or more[7]. There are two basic forms of magnifiers: through the lens (TTL) and flip-up magnifiers. TTL loupes have magnifiers built into and fixed onto spectacle lenses. The most commonly used magnifications in dentistry are magnifying glasses or telescopes. Ergonomic criteria for the description and characterization of magnifications are: declination angle, working distance, and frame size and shape[8]. The angle that the eyes close towards when looking down into the work area is the declination angle. Magnifiers with a good declination angle allow the dentist to work with minimal forward movement of the head. The steeper the declination angle, the smaller the angle of forward posture. The declination angle for flip-up magnifiers is from 20° to 30°, and for TTL from 25° to 40° [6,8]. Working distance is defined as the distance from the eyes to the working area. If the working distance is too short, it can lead to excessive neck flexion and consequent complications. The optimal working distance is between 30 and 40 cm[9]. When choosing the size and shape of the frame, a magnifying glass should be required to be installed as low as possible in the frame of the bracket, depending on the pupil and convergence.

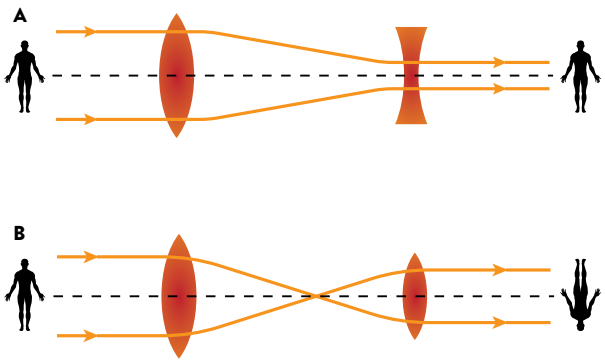


*Figure 1. Telescope system: A – Galilean; B – Keplerian (http://medical-dictionary.thefreedictionary.com/Kepler+telescope)*

## Galilean and Keplerian optical systems

There are two lens systems used in the manufacture of telescopic glasses: the Galilean system and Kepler system (Figure 1). A telescope is an optical system composed of two lenses, a lens and an eyepiece, designed to observe distant objects. The Keplerian telescope uses two converging lenses, and the Galilean telescope one convergent and one divergent lens at a distance (Figures 2, 3). Telescopic magnification systems achieve magnification of the image of the observed object on the retina by a combination of angular magnification and magnification based on changing the distance of the observed object[10]. Important terms when choosing a telescopic system are depth of field, focal length, field of view and optical aperture (lens speed). Depth of field refers to the range of distances at which the image is sharp. The sharper the depth, the stronger the magnification. Keplerian telescopes have a given depth and greater depth of field than Galilean telescopes. Focal length is the distance at which a given image magnification is seen sharply. The higher the magnification, the sharper the distance at which the image is seen, especially at close range. Keplerian telescopes have a greater focal length than Galilean telescopes for a given magnification, which makes them more comfortable to work with. Optical aperture depends on the diameter of the lens: larger lens diameters "collect" more light, thus allowing viewing even in low light[11]. Keplerian systems have a much narrower optical aperture than Galilean systems. The Galilean system is smaller and cheaper, however, its disadvantages are a smaller degree of magnification compared to the Keplerain system, and a smaller focal length and field of view for the same increase. The advantages of the Keplerian system with respect to magnification are the possibility of greater magnification, a wider field of view and a focal length greater than with Galilean systems. Its disadvantages are the fact that it is more expensive, heavier, more complex to make and more sensitive to falling or impact[12]. There are several types of telescopic magnification systems. Depending on the observation distance, there are close-up object observation systems, remote object observation systems, and combined distance and close-up systems. Depending


*Figure 2. Galilean optical system, GTX/x2,5, 350mm, integrated in the probation frame*

*Figure 3. Keplerian optical system, KF/x 3,3, 450 mm*

on the method of installation, there are hand-held systems and telescopic glasses with built-in systems in the frame. Depending on the application, there are monocular and binocular systems. Telescopic systems for observing objects at a distance are used, above all, for watching television or for use indoors in general. Telescopic systems for observing objects at close range are mostly used to look at close range at a certain distance. Their advantage is the fact that they can also be used binocularly. Combined telescopic systems are used for remote and near observation.

The basic model is for remote viewing, to which an additional lens or a system of close-up magnifying lenses is added. There are also zoom models for focusing at different distances. The advantage is the fact that there is only one basic system carrier for both distances. The disadvantage is the fact that this system is used for distance binocularly — for proximity it can only be used monocularly. Hand-held telescopic systems are practical for short-term visual tasks, especially at a distance. Also, no system carrier is required for this kind of system and it is cheaper[13].

## Telescopic glasses

Telescopic glasses are the most common way of making telescopic systems today. Their advantages are the fact that the user has the possibility of binocular use, free hands to perform other tasks and optimal positioning of the eyepiece in relation to the visual axis. The disadvantages are their noticeably higher price, the fact that they are impractical for use outside the home and for short-term visual tasks and must not be used when moving. Keplerian systems are slightly heavier than Galilean systems due to higher magnifications and can thus cause greater discomfort while wearing the telescopic glasses[12,13]. When prescribing a telescope, the following is necessary: ophthalmology refractive correction of ametropia and presbyopia, determination of eye motility status and pupillary reaction, selection and optimal adjustment of the optical system with determination of pupillary distance and vertex distance (distance of cornea tip to center of spectacle lens). This way it is possible to achieve control of the operating field and the quality of work at a certain working distance. The shape of the telescopic system carrier, TTL or flip-up system is also determined[14].

Adaptation problems such as blurred vision, eye fatigue, headache, double vision and problems adjusting to the optical system may occur at the beginning of wearing and using telescopic glasses. Adjustment time is individual[13,14].

## Conclusion

By using magnifying aids, the dentist achieves ergonomic, musculoskeletal and optical benefits and also compensates for the weakening of eye accommodation that occurs after the age of forty (presbyopia). Loupes help dentists to achieve accurate diagnoses and to enhance surgical precision when completing treatment.

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Sažetak

## GALILEJEV I KEPLEROV OPTIČKI SISTEM U DENTALNOJ MEDICINI

*I. Urlić*, *J. Pavan*, *D. Negovetić Vranić*, *Ž. Verzak* i *Z. Karlović*

Naša sposobnost izvođenja vizualnog zadatka ovisi o tome kako naše oči i vidni put percipiraju detalje u određenom zadatku. Magnifikacijska pomagala oslanjaju se na refleksiju svjetlosti kroz leće. Dentalne lupe koriste dva sistema povećanja: Keplerov i Galilejev optički sistem. Keplerov teleskop koristi konveksni lećni sistem a Galilejev konveksno-konkavni za dobivanje slike predmeta i širine vidnog polja. Veličina slike pri gledanju kroz leće ovisi o stupnju uvećanja. Dentalne lupe dostupne su od oko 2,5x, a neke se povećavaju i do 6x. Teleskopske naočale izrađene su od optičke cijevi, nosača leća i okvira nosača. Važni čimbenici kvalitete leća su rezolucija, širina vidnog polja, dubinska oštrina, optički otvor i težina teleskopskog sustava. Dentalne lupe s povećanjem u rasponu od 3,5x do 5,0x idealne su za zahtjevnije stomatološke zahvate koji zahtijevaju visoku razinu preciznosti i točnosti. Lupe olakšavaju jasnu navigaciju usnom šupljinom i pregled svih bitnih dijelova desni i zuba tijekom stomatološkog pregleda. Pružajući uvećan prikaz operacijskog polja, klinički radovi postaju lakši, učinkovitiji i sigurniji.

Ključne riječi: *lupe u stomatologiji*; *ergooftalmologija*; *Galilejev i Keplerov optički sustav*