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Magnifying Loupes in Modern Dental Practice: An Update

Abstract: There are three principal reasons for adopting magnifying loupes for operative dentistry: to enhance visualization of fine detail, to compensate for the loss of near vision (presbyopia) and to ensure maintenance of correct posture. The wearing of loupes is becoming an accepted norm amongst qualified practitioners and increasingly in the undergraduate population. However, further research is required before evidence-based recommendations can be made about their effectiveness in achieving the three principles. Compared to the medical literature, there is a paucity of studies on the use of loupes in dentistry. This article presents an overview of the well-documented (but under-researched) optical and ergonomic benefits of wearing loupes and highlights special circumstances where the use of loupes would be inadvisable. The article concludes with a review of the small number of studies on magnifying loupes specifically for restorative dentistry.

Clinical Relevance: The reader should consider the information in this article prior to the purchase of magnifying loupes.

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Many dental practitioners use magnifying loupes routinely for clinical work, and dental undergraduates are increasingly wearing them when training. Clinicians must, however, address concerns regarding potential risks to the eye when worn in the short term, and when worn throughout the working life of a practitioner, before recommending the universal use of loupes in training. Adaptation to the use of loupes takes time and this can be difficult for some practitioners.

Those who champion the routine use of loupes in dental practice have emphasized both the optical and ergonomic benefits of magnification. Advocates suggest that operating without loupes puts the practitioner at a visual disadvantage, and may also result in chronic musculo-skeletal problems due to poor posture. The purpose of this article is to address the issues surrounding the use of loupes in routine clinical practice.

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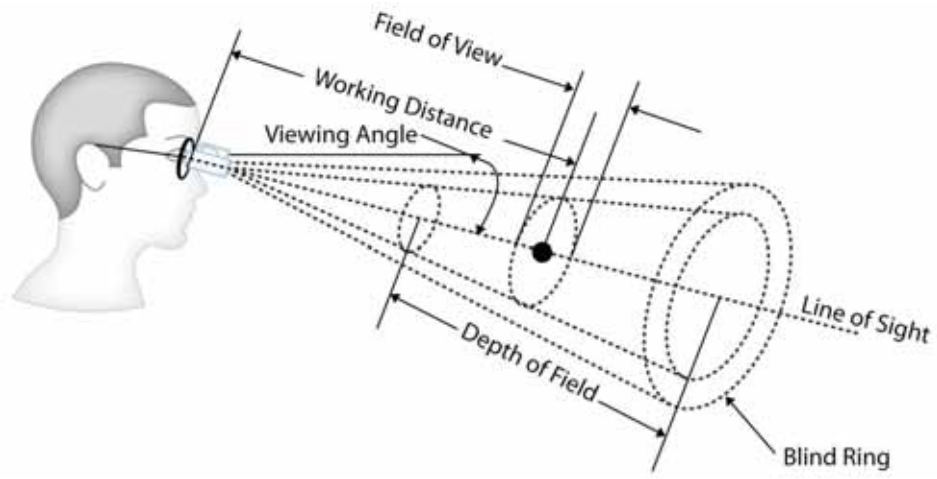

Figure 1. Optical terminology.

Vision and optics

Several accounts of the physiology of human vision with respect to loupes have appeared in the dental literature. The reader is directed to several articles for further reading.[1–3]

There are a number of optical principles specifically related to magnifying loupes that are important to the wearer:

- The field of view;
- The depth of field;
- The declination or viewing angle; and
- Individual loupe design, including co-axial illumination.

These will be considered in turn (Figure 1).

Field of view

As the magnification increases, the field that can be viewed decreases.[2] 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

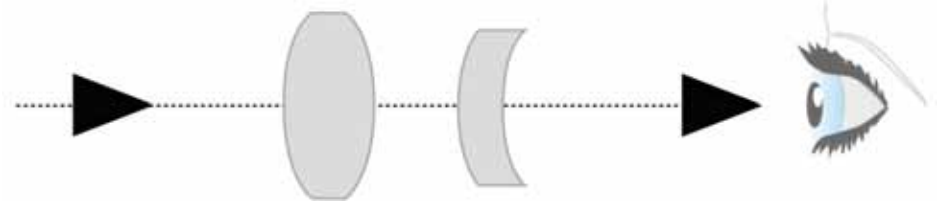

Figure 2. Galilean optics.

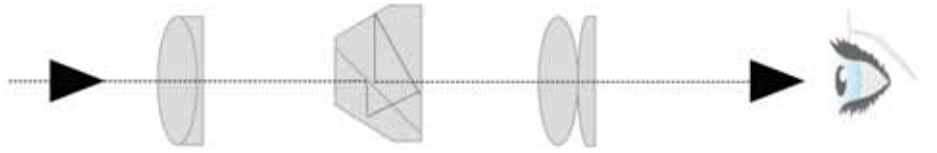

Figure 3. Prismatic optics.

Figure 4. Galilean loupes ('flip-up')

Figure 5. Galilean loupes (through-the lens).

see multiple quadrant areas in focus. 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.

Depth of field

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. 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.[2] At high magnification, slight movements of the operator or patient will result in loss of focus of the area under examination, making working more difficult.

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 sight line[4] (Figure 1). When operating, the greater the angle with respect to this line, the greater the neck tilt necessary to view the object.[5] It is ergonomically important to make sure that this angle is correct for the individual, in order to minimize strain on the neck, back and shoulders.

Loupe design

There are two optical systems used in loupes: Galilean (Figure 2) and Prismatic (Figure 3).

Galilean loupes (Figures 2, 4 and 5)

This is the more common system. The practical range is limited to x3.5 or less, as the system is limited by spherical aberration: the flatness of the field from top to bottom and left to right begins to distort the image quality as magnification increases. An additional consideration is that all Galilean lens systems produce a halo effect at the periphery of the visual field which, in some cases, may be bothersome. They are, however, relatively light in weight and low cost.

Prismatic loupes (Figure 3)

These provide the highest optical quality available today.[6] In Prismatic loupes the passage of light is lengthened through a series of internal reflections via a Schmidt prism, thus allowing the barrel of the loupe to be shortened sufficiently for spectacle or headband mounting. These loupes provide improved quality of magnification, wider fields of view and greater depth of field. The disadvantages are that they are heavier, have long barrels and are more costly. They can be used for all levels of magnification.

Recent developments in optical technology have led to the manufacture of Galilean loupes with improved optical quality. This may mean that the heavier Prismatic loupes will become outmoded, even for greater magnification.

The lenses of both types can be mounted on to the spectacle frame (Figure 4), or embedded in the spectacle lens (Figure 5). Adjustable frame-mounted loupes give the clinician the ability to adjust the interpupillary distance individually, together with the convergence, horizontal and, in some cases, declination angulations. This may often be a lengthy and fiddly process. However, individual prescription lenses are easily placed in this type of design. The major disadvantage of this type of design is the weight which, after a busy clinical working day, will be noticeable. The manufacturers have counteracted this by employing lighter 'sunglass' type frames and plastic lenses.

Loupes fixed to the spectacle lens, though lighter in weight, are more costly and cannot be flipped out of the way, for example when stepping back to get an overall look at work or when discussing the treatment with a patient. Individual correction factors must be built into these loupes rather than the lenses of the frames,[2] and small adjustment errors are likely to cause eyestrain when worn for periods longer than 30 minutes.[2] It is important that loupes conform precisely to individual requirements, so a detailed examination and fitting are required for these loupes.

The benefits of magnification

The three principal benefits of magnifying loupes will now be discussed in detail.

Figure 6. Favourable posture adopted when using loupes.

Figure 7. Co-axial LED fitting attached to loupes.

Compensation for presbyopia

Gilbert[1] reviewed problems associated with ageing, and recommended that dentists should have regular eye examinations every 2 years up to the age of 50. Thereafter, examination should be undergone every year. Burton and Bridgeman,[7] in their study of the effects of age on clinical vision, could not demonstrate any statistically significant relationship between visual acuity and working distance, but it was clear that working distance significantly increased with age. By using loupes, however, working distance can be kept at a comfortable constant, ensuring upright posture throughout the working life of the practitioner.

Ergonomic benefits

Valachi and Valachi[8,9] highlighted the need for good posture when carrying out dental procedures, as it is established that poor posture can contribute to the development of back and neck pain. Many dentists experience chronic back and neck pain[10] with figures quoted ranging from 60–80% affected individuals of various ages, from different parts of the globe.

Correct operating posture becomes doubly important for the dentist who uses magnification, as maintenance of the transverse axis of the eye in the horizontal plane is essential in order to avoid disorientation. The correct focal distance is easily achieved by moving the patient in a vertical plane, the operator maintaining an ideal posture.[1] Equipment should adapt to the requirements of the clinician, not the other way round.[4] This is certainly true, up to a point, but it must also be recognized that, when using any new equipment or method, a period of learning and adaptation is always required. There is plentiful evidence to support the contention that the use of appropriate loupes diminishes and, in some cases, eliminates chronic neck and back pain.[8–15] These studies have demonstrated that appropriate selection, adjustment and the use of magnification systems facilitate the adoption of a more upright posture (Figure 6).

Optical benefits

There is no doubt that magnification is becoming more popular as clinical techniques become increasingly demanding.[16] Some studies concentrate on the benefits of magnification as an aid to diagnosis,[17–19] although the number of valid controlled studies is small. One author demonstrated that the number, extent and direction of fracture lines in teeth could be ascertained readily using magnification and transillumination,[20] and other studies demonstrated that magnification could significantly improve the accuracy of diagnosis of caries in extracted teeth *in vitro*.[17,18]

Whitehead and Wilson [18] reported improved clinical performance when a group of *experienced* clinicians used magnification. Conversely, Donaldson and co-workers[21] could find no significant improvement when *undergraduates* wore magnifying loupes for a trial period in clinical, paediatric and operative dentistry. Another study demonstrated the benefits of magnification in fixed prosthodontic procedures in the laboratory.[22] Lussi *et al*,[23] in their study on the use of loupes in the preparation of approximal box cavities, found that loupes did not significantly decrease iatrogenic damage to adjacent tooth surfaces.

Magnification and illumination

In a study in 1996, Gultz and co workers[24] demonstrated a significant increase in visual acuity in a cohort of students and Faculty staff of all ages, as a result of using low power loupes. In a later study,[25] they explored the differences in visual acuity when using magnification with and without fibre-optic illumination: in a cohort of 70 undergraduate dental students, their results demonstrated a significant improvement in visual acuity ($P<0.001$, ANOVA) when using magnification with a fibre-optic light source. Light intensity of up to 30,000 lux is regarded as safe whilst minimizing glare. Much brighter LED lights are available, but they produce more glare, as the light is reflected from the surfaces of the teeth, and may not be safe for prolonged use (Figure 7).

Potential risks of the long-term use of magnification

There are very few instances where

light intensity and/or magnifiers cannot help corrected and normal vision. One notable exception is lack of stereoscopic vision, due to blindness or impairment of one eye. This is a great handicap to a dentist, and it would seem sensible that affected individuals be screened out before they begin their careers.[26] Individuals suffering from convergence insufficiency, however, are *potentially* at risk when wearing loupes. Convergence insufficiency occurs when the extrinsic eye muscles responsible for turning the eyes medially (convergence) appear to be weak in relation to the muscles responsible for divergence ('lazy eye'). In spite of this imbalance, the individual's eyes remain straight in all fields of gaze (compensation), resulting in 'strained eyes'. This can manifest itself as headaches, eyestrain (pain), blurred vision, or fatigue when engaged in extended periods of close work. The condition most commonly occurs in teenagers and young adults, although it can occur up to middle age.

The condition is normally diagnosed when symptoms occur but it may remain undetected as the individual sufferer may *just* compensate for the anomaly. There is then a slight risk when the unsuspecting sufferer is subjected to artificial viewing conditions, eg a restricted field of view, such as when wearing loupes. The situation would also be made worse by any misalignment or focusing error of the loupes. It is conceivable that such a person could *decompensate* if using loupes for sustained periods. This would normally produce warning symptoms such as headache but, exceptionally, might cause blurred vision which might be difficult to treat. This potential risk could be completely avoided by having a specific eye test prior to purchase, and by ceasing to wear the loupes if symptoms occur.

There is no evidence that the long-term use of magnification for close work carries any risk for the majority of individuals and it is agreed amongst workers in the field of optometry that using magnifiers routinely does not harm or weaken the eyes, nor does it cause the user to become compromised in any way.[27]

The future

Current techniques in dentistry place greater demands on vision and posture than ever before.[10] Until recently, it was suggested that undergraduates should not be required to purchase loupes, as the tolerance for error in dental preparations is so great that finer vision contributes little to product improvement.[1] Many dental schools worldwide now actively encourage their undergraduates to use magnification whilst training.[28] Benefits such as improved musculo-skeletal comfort and possibly improved confidence are as important for dental trainees as for qualified practitioners. In spite of the increase in their popularity, there is a lack of objective evidence that they should be regarded as essential items of equipment for the modern practice of dentistry. There is an urgent need for controlled studies to provide the profession with the necessary evidence on which to base recommendations.

Summary

Magnifying loupes may be worn successfully by most dental practitioners but a period of adaptation is required. There are a number of different systems available on the market, some more costly than others. It is important that the loupes are correctly fitted, in order to minimize eyestrain. Further studies are required, however, before loupes can be universally recommended.

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