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Selection and Application of Appropriate Magnification Aids In Prosthodontics: A Qualitative Review

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Abstract

Advent and evolution in the magnification aids has provided new dimensions to dentistry, by challenging clinicians' in establishing a quantifiable precision, repeatability and reproducibility in their treatment outcomes. Among the wide range of magnification aids available, the difficulty in deciding one's own magnifying aid is real. The learning curve associated with every magnification aid is associated with proper selection and needful customizations, which is based on individual variations and clinical requisites. This qualitative review attempts to serve as a guide to clinicians, in simplifying the basic optical properties and how to decide the appropriate magnification aid for an individual. We attempt to customize the degree of magnification needed for various procedures in the specialty of Prosthodontics. With the numerous inbuilt options available and multiple magnifications in a single device; usefulness irrespective of varied dental specialty is certain. However, with every possible advancement the added weight of the device still remains a limitation leaving a compromised ergonomic position especially with longer working hours in a dental operatory; which still remains a gap to be bridged.

Keywords: Magnification aids, Magnifying Loupes, Dental Loupes, Magnification in Prosthodontics, Selection of Magnification Loupes.

Introduction

Prosthodontics is a field, wherein multiple aspects of restoration of a missing dental structure is to be considered. Functional aspect of prosthetic restoration decides the overall success of the treatment; while, esthetic detailing is the governing factor for patient satisfaction. With recent scientific advances and social platform exposure, patients' expectations are much inclined towards esthetics.[1]

With the advent and evolution of magnification aids, it is possible for a clinician to provide a quality treatment via better visual perception of the operating filed. Magnification evolving as a "New-Normal" is not an unheard term in dentistry.[2] Yet, Usage of it pertaining to Prosthodontics is yet to be adequately explored. Unlike Endodontists and Periodontists, Requisites of a Prosthodontist varies with respect to clinical procedures. On analyzing the existing literature evidences, generalized data are available regarding magnification; yet, established guidelines for selection of magnification system for a Prosthodontist still remains a gray area.

Magnification maybe described as the process of resolving an object of interest, to visualize a greater detail of the same; than that visualized with human naked-eyes.[3] To understand the need for magnification, one has to analyse the limitations associated with prosthetic procedures in naked eye vision.

Theoretical visual acuity of human eye is about 70 µm. With changes in the medium, the acuity reduces to 150-200 µm. In Dentistry, these values get further deteriorated with improper illumination, as in buccal cavity.[4,5] Without the assistance of magnification aids, human naked-eye has the ability to resolve/ distinguish 2 discrete lines which are separated by a distance of 200 µm (0.2 mm). This data is scientific evidence-based, as most of the clinicians couldn't visualize an open margin, smaller than 0.2 mm.[4] Natural vision tends to degrade above the 5th decade of life, which is a physiological and unavoidable change associated with ageing.[4, 6, 7, 8] Current norms demand a minimum restorative thickness of 0.1 – 0.3 mm; wherein, accuracy of preparation is as high as 0.1 mm & this is beyond the discriminative capacity of human naked- eyes.[1]Tooth/teeth preparations performed with naked-eye is not quantifiable – in-terms of Tooth removal volume, position & refinement of shape of edge.[1, 9,10,11] Intra-operator & Inter-operator Repeatability and Reproducibility may not be satisfactorily achieved in case of precise tooth preparations. All these limitations can be overcome, by incorporation of magnification aid in the dental / prosthodontic practise.

Historical Perspectives of Magnification AIDS

Dr. William Atkinson is to be acknowledged for his publication in 1866 on the subject of magnification science and its application in dentistry for intraoral magnification via optical aids.[12] To check intraorally gold edges, fissures, and cracks in teeth, Dr. Parsons advocated the use of a large two- to three-inch diameter magnifying lens with a handle in 1873.[13]

The first surgical loupes date back to 1876 and consisted of simple loupes attached to a spectacle frame or a headband. These were made of convex lenses that were decentred to allow convergence and to use the prismatic effects of the periphery. Carl von Hess used such a loupe together with an electrical illumination device attached to a headband.[14] In 1886, a mechanic named Westien constructed a binocular instrument from two loupes to be used by a zoologist. Von Zehender later attempted to modify these loupes for use in ophthalmology, and the Zehender-Westien double loupe was born.[14] It had a firm base and a lens for lateral focal illumination. By 1912, Von Rohr and Stock had constructed a spectacle loupe that was lighter and less magnifying than Westien's.[14] It had a working distance of 25 cm and a magnification of 2X. Gullstrand was the first to use these loupes starting the development of a binocular loupe that could be attached to spectacles and bifocals.[14] This model is still used today by ophthalmic surgeons for a variety of surgical procedures.

Dentistry demands "Proper Visualization" of the operating field – for accurate diagnosis & efficient

treatment planning-cum-execution. This in-turn imparts an unparalleled importance on "Optical Magnification". In **1953,** the Carl Zeiss Company of West Germany marketed the first commercial binocular operating microscope[17] which utilized in the field of medicine for microsurgical procedures in late 20th century with further refinement. The usage of optical magnifying microscope in Dentistry was pioneered by Apotheker & Jako in 1978.[15] Evidences relating association between magnification with microscope and dentistry in-terms of Publications can be traced back to 1984, by Coburn DG.[4] However, an ergonomic dental operating microscope (DOM) for endodontics was first introduced by Dr. Gary Carr[16] .

Magnification AIDS

Based on scientific evidences, the magnification aids available for use in dentistry till date are Simple Magnification Lens, Loupes, Dental Operating Microscopes and Laboratory Stereo Microscopes.[1-15] (Figure 1)

a. Simple Magnification Glass/ Lens

Simple magnification glasses or lenses are 2-3 inches diameter lens with handle, permissible with degree of magnification varies from 1.5x to 3 x.[17] In the field of prosthodontics, the simple magnification lens was used for inspection of the laboratory procedures and details of prosthesis like contact point, embrasures, marginal adaptation, internal surface of castings and so.[17] However, clinical application of magnifying glass is very less acceptable due to various reasons such as lack of convenience, posterior inaccessible areas and indirect view in maxillary arch (posterior teeth) cannot be visualized. Also, even in the laboratory usage, the limitations exist in terms of reduced working distance, lack of higher magnification and ergonomic demerits.[2,17]

b. Dental magnification Loupes

Dental loupe systems are small binocular magnification devices, designed to be held or worn close to the eyes. With continuous advent & refinements in design as per application demands and ergonomic ease, the various types of dental loupe systems are evolved and presently dental loupes are most widely used magnification aids in clinical Prosthodontics. [2,3,5-11] (Figure-2)

The basic difference among various loupe systems is based on the optical properties they utilize for magnification.[2,5] Simple loupe systems use a pair of simple convex lenses for magnification.[2,5] The compound loupes are designed on two principles namely Galilean and Keplerian principles.[5-11] Galilean principle uses lenses combining concave and convex surfaces for magnification.[5-11] The Keplerian system and Prismatic loupes, on the other hand, use a set of prisms and a convex lens to magnify object of interest.[5-11]

Every loupe system is unique in its own way and its applications and has its own advantages & disadvantages in terms of ergonomic ease, weight, degree & freedom in magnification and chromatic abberation.[2,3,5-11] (Table 2) Among the loupes, Galilean loupes are well-suited for carrying-out routine prosthetic procedures with ease; over prismatic loupes.[2,3,5-11] While, prismatic loupes offer the most precise vision without spherical aberrations; with demerits of protruding lens and increased weight and cost – with increasing resolution. [2,3,5-11]

Most of the loupes systems are available in 2 basic designs, namely – Flip-up & TTL (Through-The-Lens) . Each system with specific design has its own merits & demerits.[10] (Table-3) Among loupe system, Flip-up model carries lot of advantages, with increased weight only being the demerit – on comparison with TTL (Through-The-Lens) model. [2,3,5-11]

Apart from these, other designs of loupe systems are based on their freedom in degree of magnification, namely: Loupes with Fixed magnification and Loupes with Freedom of magnification range. Loupes with fixed magnification have only one magnification like 2x and if a clinician wants to improve his degree of magnification to 3.5x overtime, he has to either get a new loupe or customize the existing frame with a new lens. On the other hand, in the loupes with freedom of magnification there is an adjustable range of magnification 2-in-1 or 3-in-1 or 4-in-1 magnification systems. They have multiple magnifications inbuilt in the same loupes system. Example: Orascoptic EyeZoom™ with 3-in-1 variable magnification incorporation 3x,4x & 5x magnification in the same loupes (Figure-3). Similarly, 4-in-1 magnification loupe systems are available in ExamVision Kepler Advanced model with 4 adjustable magnifications of 3.6x, 4.5x,5.5x&6.4x in the same loupe.

The loupes improve visual acuity, but this improvement is significant when their use is combined with **illumination.** Headlights are commonly offered as a portable optional extra with a cable and power pack for illumination ; some companies offer wireless options as an all-in-one design. Lights can be LED or fibreoptic. LED lights are more energy efficient, but fibreoptic lights are more intense[27]. Cross-contamination was a heightened concern as dentists had to manually turn their headlights on and off.

Manufactures now offer touch-free headlights activated by the clinician's head movement to eliminate this cross-contamination risk. These touchless light systems clip into the loupes and do not have a heavy cord or battery pack to wear. Instead, they come with three power pods and a charging unit. Newer headlight technology also uses colour-neutral LED lights that emit the lowest blue light for eye protection and unsurpassed colour accuracy. A recent advance in dental illumination is the use of fluorescence activating headlights. When combined with filtered loupes, these headlights help support minimally invasive restorative treatment by allowing clinicians to actively visualize and differentiate diseased and non-diseased tooth tissue. In addition, the hands-free system allows dentists to easily identify resin degradation, enamel demineralization and bacterial contamination, detect supra- and subgingival calculus, and identify accumulations of active periodontal bacteria around teeth and implants. Wireless integrated multiwavelength LED headlights that allow operators to easily switch between daylight, violet light and fluorescent illumination[28] are also available.

c. Optical Microscopes

It is an optical instrument that uses lens or an arrangement of lenses to magnify very small object that are too small to see with naked eye.

Laboratory Stereo Microscope can attain magnifications of 10x to 30 x to improve visibility. The permissible magnifications of laboratory stereo microscope are up to x80. However, it is advised to work at or below x30 for all practical purposes. l5x magnification promises to be comfortable.[4,17] In prosthodontics, its clinical use is limited. However, there are multiple lab-side applications, including ceramic build up, die trimming, examination of prosthetic connections and embrasures, finishing of internal casting surfaces, marginal fit inspection, and lots more.[17]

Dental Operating Microscopes (DOM) offer an adjustable range of magnification from 2x to 30x. However, working under a magnification greater than 20x is practically impossible.[4] With increasing magnification greater than 20x, DOF will considerably

reduce; even with normal breathing of the patient, focusing FOV gets very much difficult and frequent adjustments, fine tunings and diopter adjustments are anticipated.[4,17] DOM is more essential for an endodontist. Prosthodontic uses of DOM are very limited and most of the magnification work of clinical Prosthodontics are well within the range of a loupe system.

All the optical microscopes had inbuilt source of illumination with facility to adjust the intensity of light as per requirements.

Maintenance of Magnification AIDS

Maintenance of magnification aids vary, based on manufacturer's guidance. Few manufacturers provide microfiber cloth for cleaning the lens part of the magnification system. This is effective, yet using the cloth may lead to micro scratches on long-term duration. However, autoclaving the magnification aids are not recommended.[4,8]

Sterilization of the lens part still remains to be explored, as cold sterilization via chemical solutions such as glutaraldehyde and iodophor can also have a threat to etch the lens, leading to aberrations. 70% isopropyl alcohol is suggested by various manufacturers for wiping the lens part using a wetted microfiber cloth.[4,8] Cleaning the magnifying lenses may be necessary more than once for some procedures, involving multiple dental preparations.[8] Trying not to put the lenses against any sharp articles, and consistently utilize the case that are provided to secure them is good in terms of maintenance of loupes.[8] A better way for a long-term maintenance of any magnification aid is through periodic inspection through the manufacturers themselves.[4,8]

Selection of Magnification AIDS

Understanding of some fundamental Optical Properties associated with loupe magnification systems viz. Field of View (FoV), Depth of Field (DoF), Declination angle(DA), Working distance(WD), Inter Pupillary Distance(IPD) and Convergence Angle(CA) are the key behind selection of one's own Magnification Loupes[2,6,19,20, 21] specifically utilized for the clinical and laboratory prosthodontic purposes.(Table-4)

All optical properties are interrelated and influenced by many other factors like aperture size of loupes, F-number of lens and quality of lenses which are under the control of manufacturers(Table-5). Similarly, anatomical feature of an individual like height, length of arms, prominence of cheek bone with respect to eye balls may influence many of the mentioned optical properties like DA, CA and IPD (Table-5). The dental clinical area positional setup like narrow/ wide body of dental chair and saddle type operating stool may also influence some optical properties like DA and WD (Table – 5). Optical properties of a loupe with fixed manufacturer's specifications (which lacks the provision to adjust the mentioned optical properties), anatomical variations of individuals and specific clinical set up cannot be altered.

Manufacturers has developed a single loupe with provision to adjust some optical properties like IPD, DA and DoF to some extent on the cast of little compromising the ergonomic ease . But development of fully adjustable loupe without compromising ergonomic ease and comfort of the individual is still a distant dream. Hence a careful customization of the loupes, to compensate for anatomical variations in individual, specific clinical set up and application requirements may be made possible by manufacturers . The precise customisation of loupes will also help in faster learning curve of a clinician.[2,19] A golden rule to remember while selection of loupes is "Its always the equipment that has

to be adjusted to clinician's convenience and not the other way!"

In case of DOM (Dental Operating Microscope), there are many parts and specific functions of those parts in adjusting all the parameters like DOF, IPSD, CA, Magnification degree with respect to every procedure.[4] All the above-mentioned factors are inbuilt in DOM for completely adjustable variations. Hence, for DOM the learning curve is steeper comparatively than loupes.[4,16] But higher cost and difficult portability are limitation compared to the loupe.

Application of magnification in prosthodontics

Prosthetic clinical procedures associated with removable prosthodontics, temporomandibular disorders, maxillofacial prosthetics has very limited demand of magnifying aids. However, laboratory evaluation of occlusion, appliances and prosthesis can be performed under magnification for better treatment outcomes.

The conventional fixed prosthodontic procedures involving tooth preparation at various levels necessitate magnification aids. Full Mouth Rehabilitation procedures are time-consuming and demand a broader field of view and high depth of field; hence, an optimal magnification of 3.5x – 4x will offer maximum ergonomic comfort to the clinician from frequent adjustments in position during the procedure.

The advanced fixed prosthodontics involve MIPP (Minimally Invasive Prosthetic Procedures), laminates, veneers, smile designing and full mouth rehabilitation.[1] All these procedures impose a greater dependency on magnification aids and offers an excellent clinical outcome both in terms of function and aesthetics. The accuracy requirement for minimal invasive procedures is 0.1-0.2 mm.[1] Earlier, bond space of 0.5mm overall reduction of tooth tissues was considered 'ideal'. Later, Nattress & Cherukara stated that uniform overall reduction (of 0.5mm) potentially causes dentin exposure in cervical thirds of teeth.[23,25] Which later explained on basis of the reports of Ferrari[23] revealing varying Enamel thickness in different coronal areas with special attention in the cervical region , where thickness is less than .5 mm for all teeth in aesthetic zone. Thus, a uniform reduction of the enamel, especially in aesthetic zones is no more entertained for minimally invasive preparations.[23,24,25] Such a precision can be achievable, only when the Operating field is brought close-enough to operator's view – which is nearly impossible, Without Magnification Assistance.

Based on scientific literature[22]and author's experience, various conventional and advanced FPD procedures requires varied degree of magnification (Table-6)

The field of implantology is gradually getting inclined to minimally invasive implantology, with greater importance being placed on pink esthetics. The scientific evidence[26] supported that minimally invasive implantology is better performed with varied magnification.(Figure -7)

Discussion

By analysing the existing literature, it's evident that most of the resolution requirements of prosthetic clinical and laboratory procedures lies in the range of 4x - 15x magnification.[2,6,22,24,26] A Dental Operating Microscope (DOM) is undoubtedly the best magnification aid; however, a prosthodontist can do justice with an optimal magnification of 4x-6x with loupes.

Regarding the magnification system to be used, Prosthodontists who are in need of precision has prismatic loupes to back up with higher degree of magnification of range 6x-8x; with progressively increasing weight also. However, Galilean loupes are decently fine with comparatively lesser magnification levels till 3.5x; reduced weight and cost – but literature

evidence quotes Spherical aberrations, as their disadvantage. TTL (Through-The-Lens) loupes models are customized to an individual; while a Flip-up model with adjustable IPD encourages a group practice, as in institutional set-up or clinical set-up with multiple practitioners. Yet, one has to be cautious of weight and screw loosening of the flip-up portion of the loupes. TTL models can be customized with incorporating lens to compensate for varying eye sight defects; while Flip-up models does not have such provision.

For a Prosthodontist, Magnification Loupes will be an imperative armamentarium to offer a stellar clinical practice. One should be beware in selection of the magnification aid, based on their field of interest, affordability and optimal degree of magnification for successful treatment outcome.

Future scope of magnification AIDS

With improvisation in lighter materials utilizing fibres, fibreoptics, titanium frames, nasal bridge adapters to the framework of loupes, weight of the loupes have been managed for working long hours. However, lighter materials for the optical lenses and prisms without compromising the quality of magnification will reduce the overall weight and consequently alleviating the discomfort associated with long working hours for clinicians.

Portable Dental Operating Microscopes which can be easily installed in any dental operatory still remains a scope of development and proved to be boon in the field of minimal invasive dentistry.

Conclusion

Owing to the limitations of naked vision, which has a limited acuity and gradual deterioration with physiological ageing – along with added demand of precision and accuracy; practicing prosthodontists are inescapable from evolving into a “Savvy Clinician” via magnification assistance.

Evolution in design and optical advancements have permitted to perform most prosthodontic procedures with optimal precision under loupes. Prismatic loupes can be recommended as most advantageous magnification aid, with least chromatic aberrations. For laboratory procedures and inspection of prosthesis, stereo microscope can be considered the magnification aid of choice.

Abbreviations

DOM – Dental Operating Microscope

TTL – Through-the-Lens

CA – Convergence Angle

DA – Declination Angle

IPD – Inter Pupillary Distance

WD – Working Distance

FoV – Field of View

DoF – Depth of Field

References

1. Yu H, Zhao Y, Li J, Luo T, Gao J, Liu H, Liu W, Liu F, Zhao K, Liu F, Ma C, Setz JM, Liang S, Fan L, Gao S, Zhu Z, Shen J, Wang J, Zhu Z, Zhou X. Minimal invasive microscopic tooth preparation in esthetic restoration: a specialist consensus. Int J Oral Sci. 2019; 11:31.
2. Bonilla ED, Mishail D, Zhang E, Hayashi M, Pameijer CH. Hallmark of Dentistry: The Evolution and Benefits of the Dental Magnifying Loupe. Journal of the California Dental Association. 2023 Jan 1;51(1):2176579.
3. Pecheva A, Tsanova S, Raycheva. In Vitro Evaluation of the Impact of Optical Magnification on the preparation for Veneers. J IMAB. 2020; Apr-Jun; 26(2): 3155 - 3159.

4. Carr GB, Murgel CA. The use of the operating microscope in endodontics. Dent Clin North Am 2010; 54:191–214.
5. Wajngarten D, Garcia PPNS. The use of Magnification and Work Posture in Dentiatry - a Literature Review. Brt J Med & Med Res2016; 18(8): 1-9.
6. James T, Gilmour A. Magnifying Loupes in Modern Dental Practice: An Update. Dent Update. 2010; 37: 633-636.
7. Gogiya RJ, Chandak MG, Modi RR, Bhutda P, Kela S, Chandak RM. Magnification in Dentistry: A Review. Int J Appl Dent Scieances. 2018; 4(2): 83-85.
8. Christensen GJ. Magnification in dentistry: Useful tool or another gimmick? The Journal of the American Dental Association. 2003 Dec 1;134(12):1647-50.
9. Perrin P, Ramseyer ST, Eichenberger M, Lussi A. Visual acuity of dentists in their respective clinical conditions. Clinical oral investigations. 2014 Dec;18(9):2055-8.
10. Perrin P, Eichenberger M, Neuhaus KW, Lussi A. Visual acuity and magnification devices in dentistry. Swiss Dent J. 2016 Jan 1;126(3):222-35.
11. Arnett MC, Gwozdek AE, Ahmed S, Beaubien HD, Yaw KB, Eagle IT. Assessing the use of loupes and lights in dental hygiene educational programs. American Dental Hygienists' Association. 2017 Dec 1;91(6):15-20.
12. Atkinson WH. Glasses in dental operations. Dent Cosmos. 1866;8:456–460.
13. Parsons JH. Periscope. Dent Cosmos. 1873;15:153–155.
14. Kwitko ML, Kelman CD, editors. The history of modern cataract surgery. Kugler Publications; 1998.
15. Apotheker H, Jako G J. A Microscope for use in dentistry. J Microsurg. 1981; 3: 7-10.
16. CASTELLUCCI, A.: Magnification in endodontics: the use of the operating microscope. Pract. Periodont. Aesthet. Dent. 15(5):377, 2003.
17. Chou TM, Pameijer CH. The application of micro dentistry in fixed prosthodontics. J Prosthet Dent. 1985;54(1):36–42.
18. Hoerenz P. The design of the surgical microscope-Part I. Ophthalmic Surg; 1973: 440-45.
19. Plessas A, Bernardes Delgado M. The role of ergonomic saddle seats and magnification loupes in the prevention of musculoskeletal disorders. A systematic review. International Journal of Dental Hygiene. 2018 Nov;16(4):430-40.
20. Wajngarten D, Garcia PP. Effect of magnification devices on dental students' visual acuity. PloS one. 2019 Mar 27;14(3): 1-13.
21. Wynne L. The selection and use of loupes in dentistry. Dental Nursing. 2014 Jul 2;10(7):390-2.
22. Van As GA. The use of extreme magnification in fixed prosthodontics. Dent Today. 2003 Jun; 22(6):93-9.
23. Nattress BR, Youngson CC, Patterson CJ, Martin DM, Ralph JP. An in vitro assessment of tooth preparation for porcelain veneer restorations. Journal of dentistry. 1995 Jun 1;23(3):165-70.
24. Pahlevan A, Mirzaee M, Yassine E, Omrany LR, Tabatabaee MH, Kermanshah H, Arami S, Abbasi M. Enamel thickness after preparation of tooth for porcelain laminate. Journal of Dentistry (Tehran, Iran). 2014 Jul;11(4):428.

25. Cherukara GP, Davis GR, Seymour KG, Zou L, Samarawickrama DY. Dentin exposure in tooth preparations for porcelain veneers: a pilot study. The Journal of prosthetic dentistry. 2005 Nov 1;94(5):414-20.
26. Shakibaie-M B. Uses of the operating microscope in minimally invasive implantology. Quintessenz. 2010;61(3):293-308.
27. Leanna Wynne. The selection and use of loupes in dentistry Dental Nursing. Dental Nursing 2014 ; 10 (7): 390- 392.
28. Steier L, Figueiredo JAP, Blatz MB. Fluorescence-enhanced theragnosis: a novel approach to visualize, detect, and remove caries. Compend Contin Educ Dent. 2021;42:460–465.

Legend Figures

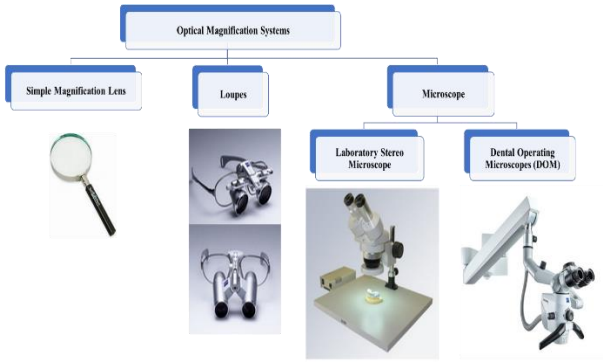

Figure 1: Magnification Aids in Dentistry

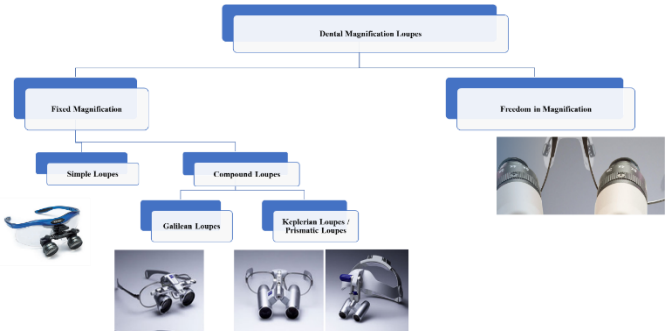

Figure 2: Dental Magnification Loupes

Table 1: Dental Magnification Loupe Systems

Dental Magnification Loupe Systems	**Optical Method of Magnification** 1. Simple Loupes (2x) 2. Compound Loupes (3x – 3.6x) a. Galilean system b. Keplerian system 3. Prismatic Loupes (4x-8x)
	Basic Design 1. Through-The-Lens 2. Flip-Up 3. Hybrid Loupes (Basically TTL design, with added provision of flipping up the objective lens part. Though few manufacturer's claim their production; much of literature evidence is lacking and this model is under Research & Development)
	Freedom in Degree of Magnification 1. Fixed Magnification Loupes 2. Multiple Magnifications in 1 Loupes a. 3-in-1 loupes b. 4-in-1 loupes

Table 2: Advantages & Disadvantages of Magnification Loupe Systems

	Simple Loupes	Compound Loupes	
		Gallelian loupe	Keplarian (Prismatic) Loupes
Advantages	- Economical - Light Weight - No need of additional Illumination	- Superior Magnification (3x) - Minimal chromatic aberrations - Increased Focal Length (30-45 cm) - Decreased Eye strain & Fatigue	- Superior Magnification (3.5x – 6x) - Highest Optical Quality, with very minimal aberrations - Increased Focal Length (30-45 cm) - Decreased Eye strain & Fatigue
Disadvantages	- Limited Resolution - Spherical & Chromatic aberrations - Poor Ergonomics - Poor Optical Properties	- Spherical Aberration - Additional Illumination Source required.	- Increased weight with higher resolution (> 4 x) - Additional Illumination Source required.

Table 3: Advantages & Disadvantages of Flip-UP & Through-The-Lens (TTL) Loupes

Design	Advantages	Disadvantages
Flip-up loupes	Use on various frames, may be flipped out of view, adjustable declination angle, adjustable Inter Pupillary Distance (IPD) enabling sharing among operators, inexpensive	Narrower field of view, heavy and bulky, risk of screw loosening at flipping junction
Through-the-lens loupes	Customized for individual operator, larger field of view, lightweight	Fixed to a specific frame, nonadjustable, expensive

Figure 3: Orascoptic EyeZoom™ with 3-in-1variable magnification incorporation 3x,4x & 5x magnifications in the same loupe

Table 4: Optical Properties to be Considered in Selection of Magnification Loupes

Properties for Selection	Description	Interpretation	Prosthodontic Correlation
Field of View (FoV)	The limited area that is visualized under a magnification loupe. (Figure 4)	Higher the Magnification, field of view will be restricted - less number of dental units will be visible. Lower the Magnification, field of view will be broader - more number of dental units and adjacent structures will be visible.	For Laminate preparation in single tooth, higher magnification and reduced FoV limited to 1-2 teeth will be preferred. For multiple teeth preparations as in Full Mouth rehabilitation, increased FoV facilitates visibility of >5 teeth at a time.
Depth of Field (DoF)	Distance within which an object remains in Focus. (Ability to focus both near & far objects, without change in position) (Figure 5)	Higher the Magnification, Lesser the Depth of Field. At higher magnification, near objects will stay focused and far objects will be out of focus. Lower the Magnification, better the Depth of filed. At lower magnification, near and far objects will be focused equally.	For multiunit preparations (say 5 unit), at a higher DOF all the 5 teeth to be prepared will be clearly in focus. Whereas, at a lower DOF 2-3 teeth in the center will be in focus and teeth at the peripheries will be out of focus. Similarly, when entire quadrant is prepared (say right upper quadrant), at higher DOF both anterior and posterior teeth will be in focus. Whereas, at lower DOF while anterior teeth remain focused, posterior teeth of the same quadrant will become blurred and vice-versa.
Declination angle (DA)	Angle formed between Line of Sight to the focal line through lens. (Figure 6)	Greater the Declination angle, Greater the Head & Neck will be tilted to visualize the object of interest. Unfavorable ergonomic posture leading to eye strain, back and shoulder muscles strain. In cases of prismatic lens systems, there is an in-built angulation which results in clinically favorable ergonomic posture.	DA is directly associated with ergonomic posture, particularly head tilt and neck tilt. If Prosthodontist is more involved in long-standing procedures (like Full Mouth Rehabilitation), customizing the DA will offer a greater ergonomic comfort.
Working distance (WD)	Distance from the Lens to Object of Interest. (Figure 7)	Lesser the Working Distance, Better the Acuity of visual perception. Longer the Working Distance, Better Posture & Less Eye Strain.	Depending on the Length of Arms & Height of individual clinician, WD has to be customized – for Ergonomic Ease & Eye Comfort. Most used and suggested WD is 11-15 inches (28-38 cms).
Inter Pupillary Distance	Distance between Pupils of	Key Determinant in deciding the	Varies with every individual. Should be

(IPD)	Right & Left Eyes. (Figure 7)	learning curve, for every individual. Recording of the IPD by manufacturers, for customizing the loupe systems is crucial. More accurate IPD recording will ease the learning curve.	customized for early adaptation to loupe system & improved sight.
Convergence Angle (CA)	Relates the strain posed on Extra-ocular muscles, during the use of magnification aids. (Figure 7)	As the Magnification increases, Convergence angle also increases. Increased CA causes eye fatigue. Frequent relaxation via focusing on distant objects at infinity is recommended. Highly associated with IPD.	CA is directly associated with eye strain. Long standing procedures with increased CA, causes fatigue of Rectus (Medial & Lateral) muscles. Increasing the working Distance may reduce CA, hence the eye strain. Microscopes and Prismatic loupes have decreased CA, with least strain to eyes.

Figure 4: Field of View (FoV) is reduced with increasing magnification. a) 1x magnification FoV is wider b) 2x magnification c) 3x magnification d) 3.6x magnification e) 4 x magnification f) 5x magnification; b-f: with increasing magnification, FoV gets restricted.

Figure 5: Depth of Field

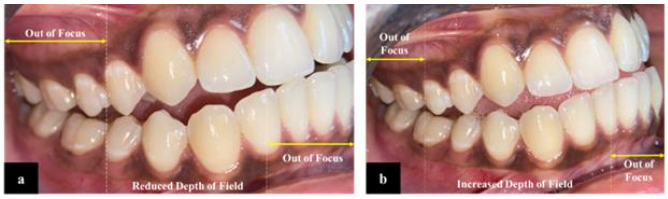

Figure 6: Declination Angle customized in a TTL Loupe

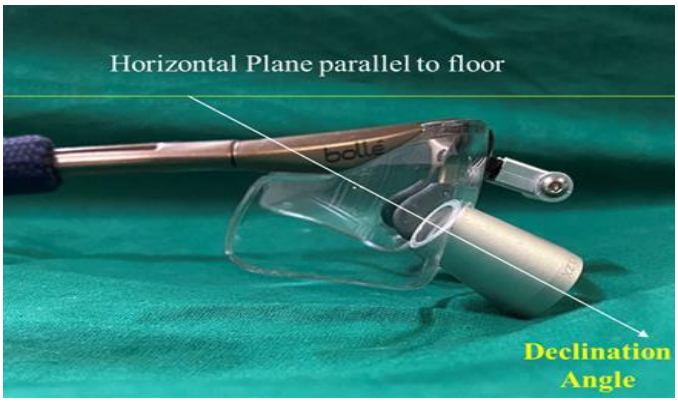

Figure 7: Convergence Angle (CA), Inter Pupillary Distance (IPD) & Working Distance (WD)

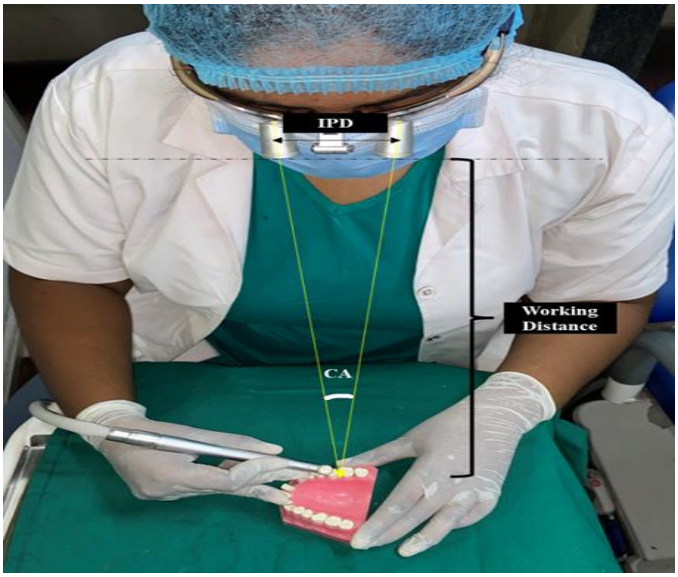

Table 5: Factors influencing optical properties of magnification aids

Factors	Influence over Optical Properties
A) Parts / Components of Instrument i. Aperture Size ii. F-Number iii. Quality of Lens	i. Aperture size influence the FoV & DoF ii. F-Number influences CA, FoV & DoF iii. Quality of lens influences spherical aberrations and chromatic aberrations
B) Anatomical Variations i. Height of Individual ii. Length of Arms ii. Prominence of Cheek bone with respect to Eyeballs	i. Increased height demands customization of DA to steeper degrees so as to avoid head and neck tilt, to favor ergonomic ease. ii. Increased arm's length demands increased WL; CA will be farther hence reduced eye strain. iii. Practitioners with deeper eyes with more prominent cheek bones, will require steep DA; than those with prominent eyes and average cheek bones.
C) Clinical Operatory Set-up i. Wide body dental chairs ii. Narrow body dental chairs / Saddle type operating stool iii. Sitting / Standing dentistry practice	i. Wide body dental chairs increases the operator-patient distance; hence increased WD and decreased DA is demanded. ii. Narrow body dental chairs and Saddle type operating stool reduces the operator-patient distance; hence decreased WD and steeper DA is demanded. iii. Sitting dentistry and Standing dentistry demands a different WD and hence DA is accordingly varied. Practitioner should take a call on predominant choice of one's own practice mode.

Table 6: Degree of Magnification for Prosthodontic Procedures

A. Conventional / implant Procedures / Full Mouth Rehabilitation	Interpretation & requirements	Recommended Magnification
Tooth Preparation: i) Gross Reduction ii) Finishing iii)Normal size single tooth preparation iv)Small size (mandibular incisor) teeth preparation v)Multiunit FPD tooth preparation,	 -Greater FoV- less magnification -Higher magnification- less FoV -Greater FoV- less magnification -Less FoV- higher magnification Higher FoV and DoF- less magnification	 i) 2.5x to 4x magnification ii) 5x to 8x magnification iii) 2.5 to 4x iv) 4x to 6x v) 2.5x- 4x
Multiple implant placements	Higher FoV and DoF- less magnification	2.5 x – 4x
Rubber Dam Placement & LA delivery	Higher FoV and DoF- less magnification	2.5x to 4x
Gingival Retraction & Cementation	Less FoV- higher magnification	4x to 6x
Laboratory Fabrication/ inspection of micro defects	Higher magnification with good FoV	10x to 16x (high magnification)
Full Mouth Rehabilitation (FMR)	Higher FoV and DoF- less magnification	3.5x to 4x
Inspection (Occlusal contacts &Tight Proximal contacts)	Higher magnification with good FoV	10x
B. MIPP procedures	Interpretation & Requirements	Recommended Magnification
Tooth preparation for Laminate-Veneers & highly esthetic demanding procedures	Less FoV- higher magnification	5x to 8x
Adhesive procedures	Less FoV- higher magnification	6x to 8x

Figure 8: Recommended Degree of Magnification in Minimally Invasive Implantology