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Review Article

Magnification in endodontics: A review of its application and acceptance among dental practitioners

Jun Fay Low[1], Tuti Ningseh Mohd Dom[2], Safura Anita Baharin[1]

[1]Centre for Restorative Dentistry, Faculty of Dentistry, Unit of Endodontology, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia,
[2]Centre for Family Oral Health, Faculty of Dentistry, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia

Correspondence: Dr. Safura Anita Baharin
Email: safurabaharin@ukm.edu.my

ABSTRACT

The application of magnification devices in endodontics is mainly meant for visual enhancement and improved ergonomics. This is crucial especially when long hours are spent in a narrow operating space to treat obscure microanatomy. Nevertheless, application of magnification in endodontics has yet to be introduced into the mainstream practice due to various influences in behavioral patterns. By conducting an extensive literature search in the PubMed database, this narrative 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 encourage clinicians to employ magnification in their practice for improved outcome.

Key words: Endodontics, lenses, magnification, optics, photonics, visual acuity, visual aids

INTRODUCTION

Endodontics is confined to narrow operating space as it deals with miniscule anatomy. As a result, clinicians who manage intricate cases appear to demand higher visual acuity.

Over the years, many magnification devices have been introduced as bridging tools between the naked eyes and the microscope. In fact, tools, such as an endoscope, magnifying glass, and intraoral camera, have largely been superseded by contemporary devices that seem to be more practical and convenient for application, such as loupes and dental operating microscope (DOM).[1-3]

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This review describes several common types of magnification devices applied in the discipline of endodontics, the factors that influence their adoption, the advantages, and shortcomings, as well as the importance of using magnification devices for endodontics.

METHODOLOGY

An extensive literature search had been carried out by combing through the PubMed database. The MeSH keywords applied were "endodontics," "visual

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aid," "optics and photonics," "lenses," "surveys and questionnaires" and "visual acuity." As a result, a total of 670 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 80. Breakdown of relevant articles according to the type of instruments is displayed in Table 1.

LIMITATION OF THE NAKED EYES AND SIGNIFICANCE OF MAGNIFICATION DEVICES (REARRANGED)

Unaided eyes can only see up to the level of canal orifice.[4] Moreover, natural vision would begin to deteriorate at the age of 40.[5] This circumstance has been verified by using miniaturized eye charts placed in teeth.[6] Lack of awareness of this visual handicap is a problem within the dental profession.[7] Nevertheless, age-related visual disability seems to minimize with the use of loupe and could be compensated by using the DOM.[6,8]

Table 1: Breakdown of relevant articles according to the type of magnification device

Number	MeSH keywords	Result (number of articles)
1	Articles pertaining to loupes	15
2	Articles pertaining to operating microscopes	33
3	Articles pertaining to loupes and operating microscopes	15
4	Articles pertaining to magnification in general	10
5	Articles pertaining to others (endoscope, intraoral camera, magnifying glass, etc.)	7
6	Total number of relevant articles reviewed	80

PREVALENCE OF MAGNIFICATION DEVICES USAGE

The reported data on the prevalence of use appeared to be limited. Nevertheless, an increasing trend was noted in the United States and the United Kingdom.[9-12] This reflects the increasing demand for enhanced visual details to achieve clinical excellence in endodontics. Besides, other studies that reported the prevalence of use of magnification devices are shown in Table 2.[7,13-19]

TYPES OF MAGNIFICATION DEVICES

Essentially, loupes are available in several forms as noted in Table 3. In general, flip-up loupe differs from through-the-lens (TTL) loupe in terms of barrel mobility, weight and cost.

Some trendy TTL design may have a small frame rim that does not permit the loupe to sit lower for a steeper declination angle. This may pose some ergonomic challenge requiring additional head tilt. Thus, clinicians must strike a balance between esthetics and ergonomics when selecting the frame design. This is contrary in flip-up loupe as declination angle can be freely adjusted.

On the other hand, DOM seems to offer better ergonomics and wider range of magnification. Nonetheless, the two major shortcomings of DOM are its high cost and lack of portability.

Table 4 presents a comparison between loupe and DOM. Currently, the gold standard for the practice of endodontics necessitates the application of a microscope.[22]

Table 2: Articles that reported the prevalence of use of magnification devices

Study	Sample size, *n*	Country	Operator	Prevalence (%)		
				Loupe	DOM	Loupe and DOM
Forgie *et al*. 1999	1280	UK	GDP	9	-	-
Mines *et al*. 1999	2237	US	Endodontists	-	52	-
Burke *et al*. 2005	701	UK	GDP	26	-	-
Thomas and Thomas 2007	868	US	Dental hygienist	60.5	-	-
Kersten *et al*. 2008	1091	US	Endodontists	-	90	-
Farook *et al*. 2013	153	UK	GDP	31	-	-
Savani *et al*. 2014	479	US	GDP	75	2	-
Neukermans *et al*. 2015	826	Belgium	GDP and various specialists	-	-	47
Alrejaie *et al*. 2015	318	Saudi Arabia	GDP and endodontists	-	47	-
Eichenberger *et al*. 2015	69	Swiss	Private practitioners	64	-	19
Ferreira *et al*. 2017	279	Brazil	Endodontists	23.66	35.48	8.24
Topkara *et al*. 2017	275	Turkey	GDP and endodontists	12.4	1.8	-

UK: The United Kingdom, US: The United States of America, GDP: General dental practitioner, DOM: Dental operating microscope

Table 3: Main differences between flip-up loupe and through the lens loupe

Features	Types of loupes	
	Flip-up	TTL
Barrel mobility	Can be flipped out of sight when not in use	Fixed. Barrels may hinder eye contact during communication
Optics adjustment	Interpupillary distance, convergence angle and declination angle can be changed	Not needed
Sharing among operators	Permitted	Not possible
Weight	Heavier due to the hinges	Lighter
Cost	Relatively cheaper.	More expensive
Prescriptive eyewear	May be worn with the loupe or incorporated into the frame	Can be incorporated into the frame

TTL: Through the lens

Table 4: Main differences between loupe and dental operating microscope

	Loupe	Dental operating microscope
Cost	Cheaper	Significantly more expensive
Portability	Portable and light Allows practice in multiple locations	Floor standing microscopes are portable but take up space and are very heavy to shift While, mounted microscopes are fixed to the ceiling or wall
User adaptability	Easier	Steeper learning curve
Ergonomics	Slight head tilt may be required depending on the degree of lens declination	Perfectly neutral body posture
Level of magnification	Reasonable but fixed and limited (2.5×-8.0×)	A higher level of magnification is available which can be adjusted (3×-30×)
The line of sight and eye strain	The convergent line of sight leading to eye strain over a long duration of use[20]	A parallel line of sight allowing more relaxed eye muscles[21]

USES OF MAGNIFICATION DEVICES IN ENDODONTICS

Many scenarios have greatly benefited from the use of magnification in endodontics. In fact, this directly influences the decision-making in saving previously thought non-restorable tooth. The enhanced vision and illumination can facilitate the following:

- Diagnosing caries and minute crack[23-25]
- Conservative access opening[26]
- Identifying obscure anatomy[27,28]
- Managing sclerosed canals[29]
- Confirming canal cleanliness prior to obturation[30]
- Outlining and removing pulp stones[31]
- Managing perforation and tooth resorption[32,33]
- Retrieving silver point, separated instrument, and fractured post[34-36]
- Smaller osteotomy, magnified inspection of resected surface, as well as retropreparation and retrofill in endodontic microsurgery.[37]

Table 5 showed the prevalence of additional anatomy found with and without using visual magnification. It is apparent that diagnostic power is associated with the level of magnification.[28,38-44]

VARIABLES ASSOCIATED WITH THE DIFFERENT LEVELS OF MAGNIFICATION

The two variables directly associated with the levels of magnification are field of view and depth of field (i.e., the range of working distance where an object stays in focus). At higher magnification, the field of view seen is reduced and the depth of field is smaller.[20] A clinician who utilizes higher magnification loupe for endodontics may find it challenging to perform other procedures that require a wider field of view and depth of field.

In contrast, recent microscopes are equipped with continuous range of magnification to accommodate smooth change in the visual field. Some models have motorized control for focusing and magnification to suit the wide range of tasks being performed.

USES OF VARIOUS LEVELS OF MAGNIFICATION IN ENDODONTICS

Adjustments of magnification can be categorized into three levels:[45,46]

Low magnification (3x – 8x)

Appropriate for examination of tooth orientation and positioning of bur or ultrasonic tip. The wide field of

Table 5: Prevalence of additional anatomy found with and without visual magnification

Study	Type of study	Anatomy investigated	Visual magnification (%)		
			Unaided eye	Loupe	DOM
Burhley *et al*. 2002	*In vivo* (clinical)	MB2	18.2	55.3	57.4
Schwarze *et al*. 2002	*In vitro*	MB2	-	41.3	93.7
Baldassari-Cruz *et al*. 2002	*In vitro*	MB2	-	51.3	82.1
Alaçam *et al*. 2007	*In vitro*	MB2	-	62	74
Paliwal *et al*. 2011	*In vitro*	MB2	66.6	-	92.5
Park *et al*. 2014	*In vitro*	MB2	-	15.8	70.5
Nath and Shetty 2017	*In vitro*	MB2	68	76	100
Slaton *et al*., 2003	*In vitro*	Dentinal crack	39	45	53

DOM: Dental operating microscope, MM: Mid mesial canal, MB2: Mesiobuccal canal

view allows comparisons of the adjacent anatomic landmark. This magnification level is used in loupes in which straightforward cases can still be competently performed.

Medium magnification (8x – 16x)
Commonly used in non-surgical and surgical endodontic procedures as it provides an acceptable field of view and depth of field. It is used for performing intricate procedures such as perforation repair, separated instrument retrieval and surgical procedure which requires higher precision and accuracy.

High magnification (16x – 30x)
Employed mostly for close-up examinations and inspections of minute anatomies, e.g., calcified canal orifice and minute cracks. Apart from having a diminutive field of view, immediate loss of focus may ensue following minor movements. The subtle color variance between secondary and tertiary dentin in teeth with calcific metamorphosis can be distinguished at this level.

FACTORS THAT INFLUENCE THE USE OF MAGNIFICATION

Among the factors that encourage clinicians to use magnification devices are exposure to magnification devices via demonstrations and dental conferences, increasing awareness on the benefits of using such technology and health-related issues such as visual deterioration and musculoskeletal pain[7,11,14,47] The usage of this tool is further promoted via social influence by peers and colleagues when encouraging outcomes are reported.

Conversely, several shortcomings have been reported to dissuade its usage e.g. increased treatment time, steep learning curve, issues with infection control and positional difficulties especially when treating the mandibular molars.[9,10,12,14,17,47-50]

Younger clinicians with good visual acuity and the more skilled, experienced clinicians who rely on tactile sensation and anatomical knowledge are those who still not fully convinced of the benefits of using such device. They are yet to be convinced that overlooked subtle anatomy may conceal untreated areas.[38,51]

The claims of discomfort and restricted visual field could be associated with the shortcomings of working with loupe, which due to its perceptible weight and non-adjustable magnification. Although this is not the case with DOM, the associated high cost and demand for auxiliary support may restrict it as an alternative.

Concerns pertaining to the adverse effect of magnification on visual acuity and visual dependence have already been debunked.[5,6,52] Clinicians who are accustomed to rely on more visual details may find that their normal vision is inadequate without magnification. Besides, the feeling of worsening visual acuity could be due to eye fatigue after long hours of muscle contraction for a converging line of sight upon usage of loupes. Nevertheless, a short rest or an intermittent glance afar is sufficient to address such problem.

ADVANTAGES OF MAGNIFICATION DEVICES

Three primary advantages were identified in relation to the usage of magnification device in endodontics, namely, (1) enhanced visualization, (2) improved working posture, and (3) increased referral.

Enhanced visualization
Ambiguity in clinical diagnosis is minimized with enhanced visual ability.[53] Minute crack, initial caries,

and microleakage are clearly observable. Additionally, fine motor skills in endodontics can be improved with higher magnification.[54] The ability to carry out procedures at high precision prevents iatrogenic damage and permits a substantial reduction in treatment time for non-surgical endodontics procedure.[55]

Importantly, intricate cases can be managed with more certainties as the use of microscope ameliorates management of elusive and calcified canals, iatrogenic errors, as well as retreatment cases.[43,56,57]

Endodontic microsurgery performed under magnification offers vast benefits as small surgical site induced minimal trauma and reduced the risk of damaging adjacent structures.[58] Magnification also allows a thorough examination of the resected root end to rule out a fracture, isthmus, and additional canal.[59] Accordingly, the application of micro-instruments creates a deeper and well-centered retro-preparation that addresses a wider area of infected anatomy.[37,60]

LCD monitor or co-observation scope allows the assistant to become more focused and attentive during the procedure. This ascertains efficient workflow when the assistant can operate the suctioning device without obstructing the clinician's view as well as assisting with documentation.

Improved working posture

Good ergonomics allow longer working time without repetitive muscle strain.[61] A survey performed amongst general practitioners revealed that the most frequent reason to retire prematurely was musculoskeletal disorders.[62] Thus, better ergonomics conferred by magnification devices can prevent postural issues that are inherent to dentists in their career.[63]

Increased referral

The use of advanced equipment is reflective of clinicians as being more professional and skillful. As patients trust and confidence are established, more word-of-mouth referrals will ensue. A camera can be adapted to the microscope to enable the clinician to take high-resolution photos to explain the case intricacy or prognosis. This may foster understanding among patients towards the proposed treatment plan.

DRAWBACKS OF MAGNIFICATION DEVICES

Several reported drawbacks are acclimatization period of the new working environment, the high cost of the magnification device and its related accessories, additional steps for infection control, as well as a potential sharp injury at the workplace.

Learning curve

The adjustment period is steeper for devices with higher magnification.[39] Hindrance in the learning curve is especially related to senior dentists who are already suffering from eyesight deterioration. Clinicians who are familiar with loupes may find the transition to using microscope less demanding as the device set up only differs slightly.

The hand-eye coordination must be re-learned as endodontics is performed with indirect vision. This requires some practice as to establish canal or instrument orientation from an inverted image.

Precise and fine movement is essential for mid- to high-level magnification. Minor trembling, which cannot be noticed via naked eyes, could appear very pronounced under magnification.[64] This issue can be controlled by adopting a well-balanced body posture with arms placed closer to the body, in which an operator chair with arm support could be of great assistance.

In reducing dizziness during the initial period of use, clinicians should start and get comfortable with a lower level magnification (×2.5, ×3.0) before increasing the magnification. Additionally, novice users can begin with a shorter duration of use or apply intermittent break if necessary. The trial period with varied designs of magnification devices may aid clinicians to select the equipment they are most comfortable with. When operating with microscopes, clinicians wearing glasses must remember to retract the eyecups. Hinges and fixation stability also play significant roles to decrease movements that may cause dizziness.

Cost

The costs of loupe and microscope are considered impractical, particularly amidst developing nations. The separate lighting system that needs to be attached with the loupe and microsurgical instruments may also incur an added cost. Generally, the microscope is significantly more expensive than the loupe due to various optic designs that provide substantially higher levels of magnification without causing eye strain.[21,65] The heavy optics is, in turn, justifiably supported by hinges and arms that stay static in any position.

Infection control and lens scratching

One obstacle faced when working with magnification is cross-contamination. Operators who use loupe must avoid touching or changing its orientation during treatment. The assistant may help to reposition the loupe or head strap if required. The use of high volume evacuation and suitable working distance are imperative to minimize contamination. Protective cover placed over the loupe prevents lenses from scratching. Surface debris on the lenses can be removed with gentle blowing and blotting. Disinfection of the devices should follow the manufacturer's instructions and professional cleaning and servicing must be sought periodically to maintain its optimum function.

Sharp injuries in endodontics

Sharp injuries can occur due to the careless passing of anesthetic and irrigation needles, and files. Passing skills must be well-coordinated between the clinician and the assistant to avoid injuries. Besides, care is vital when clinicians bring in irrigation or anesthetic needles towards the patient. To avoid sharp injuries when passing the instruments, clinicians should peek down the microscope eyecups or loupes. Operator hand movements during instrument exchange must be limited to only the wrists and fingers to reduce the loss of focus in the visual field.

THE OUTCOME IN ENDODONTICS WHEN USING MAGNIFICATION

In long-term randomized control trials, the comparison made for outcomes of endodontic treatment with and without magnification is challenging, owing to many confounding factors.[66] However, numerous studies seem to support that treatment outcome in endodontics is enhanced with the use of magnification.[67-69] Untreated MB2 canal of the maxillary molars that were often overlooked without magnification seemed to decrease the long-term prognosis.[70] Furthermore, when endodontic microsurgery is performed under magnification with modern microsurgical methods, the success rate is 94%, as opposed to 59%, when performed with neither magnification nor cutting-edge instruments.[71]

CONCLUSION

The ability to appreciate the characteristics of magnification devices and the varied levels of magnification will encourage clinicians to use them and eventually increase their proficiency to perform endodontics procedures, hence improving the outcomes.

In the foreseeable future, the use of magnification is likely to become the standard of practice, particularly within the discipline of endodontics. Teleconsultation may also turn into a reality via live streaming when the use of these magnification devices gains wider acceptance by dental practitioners.

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