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OPTICAL DEVICES IN DENTISTRY

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Abstract

In the course of professional dental practice, the visual system is subjected to considerable strain, while an ergonomically unfavorable working posture represents an additional risk factor. The establishment of ergonomic working conditions involves the development of effective teamwork skills, including the active involvement of an assistant, as well as the use of optical magnification systems of various types. Four-handed dentistry combined with high-quality visual enhancement provides significant advantages for dental professionals. In particular, occupational risk factors such as forced posture, muscular tension, and spinal overload are reduced. Visual fatigue is minimized, while the accuracy of clinical procedures, diagnostic reliability, and overall treatment quality are significantly improved.

Keywords: Optical devices, magnification, dentistry, ergonomics.

Introduction

Contemporary restorative dental techniques require high-quality visualization of the operative field to ensure accurate reproduction and detailed assessment of small anatomical structures. Many clinical challenges faced by dental professionals can be effectively addressed through the use of optical devices that visually enlarge fine details within the working area, enhance visual acuity, and reduce ocular strain and fatigue.

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Dental caries, non-carious lesions, enamel and dentin cracks, as well as defects in teeth and esthetic restorations, can be reliably detected only with the aid of modern visualization equipment. Magnification also contributes to improved polishing quality and better marginal adaptation of restorations. Optical systems assist dentists in identifying subgingival deposits and interproximal calculus. During examination of the oral mucosa, early diagnostic accuracy can be achieved exclusively through the use of magnification systems.

Moreover, the application of optical devices represents a direct investment in the occupational health of dental professionals. Improved posture and enhanced visibility help prevent work-related musculoskeletal disorders and vision-related occupational diseases.

The present study aimed to evaluate the effectiveness of optical devices in the diagnosis and treatment of diseases affecting permanent teeth.

Materials and Methods

The study analyzed clinical cases involving the treatment of dental caries and its complications, accompanied by photographic documentation of endodontic procedures and esthetic restorative stages. The following equipment was utilized:

- Zumax Medical OMS 2350 operating microscope
- LI-2-8× monocular loupe (BelOMO)
- 2× binocular loupe (BelOMO)
- Zenit LB-1M binocular loupe
- Titanium ELKA intraoral video camera (A-dec compatible, VGA)
- Pentax K5 digital SLR camera with SMC Pentax D FA Macro 100 mm F2.8 WR lens and Pentax AF 080C ring flash

A comparative analysis of different optical devices was conducted, followed by the development of practical recommendations for optimizing visualization techniques in dental practice.

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Types of Optical Devices Used in Dentistry

Optical devices employed in dentistry can be classified into the following categories:

- Monocular loupes
- Binocular loupes
- Dental operating microscopes
- Intraoral video cameras
- Digital photographic systems

Monocular Loupes

Monocular loupes typically provide moderate magnification ranging from 8× to 12×. Due to their short focal distance, their application is limited primarily to diagnostic procedures and post-treatment evaluation. Their advantages include low weight and affordability. Some monocular loupes are equipped with measuring scales that allow for documentation of linear dimensions and angles during examination.

Binocular Loupes

Binocular loupes are more widely used in clinical practice. Galilean loupes offer magnification levels of approximately 2.0–2.5×. Keplerian (prismatic) loupes, which incorporate multiple lenses and prisms, provide higher magnification (up to 6×), superior optical clarity, and a flatter image. A working distance of 35–45 cm enables an ergonomic posture without compromising spinal alignment.

The level of image detail depends on magnification strength, visual acuity of the operator, and the presence of presbyopia. Increasing magnification inevitably reduces the field of view and depth of focus. For routine dental procedures, a field of view of at least 10 cm is considered optimal.

The working angle of binocular loupes directly influences operator posture. Smaller declination angles require greater neck flexion, which may increase

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musculoskeletal strain. Additional illumination systems can enhance visualization, although they increase the overall weight of the device.

Binocular loupes may be mounted using Flip-Up or TTL (Through-The-Lens) designs. Flip-Up systems allow adjustment of lens position, whereas TTL loupes offer superior light transmission, reduced weight, and compact size but require individualized manufacturing and do not permit angle adjustment.

Intraoral Video Cameras

Intraoral video cameras elevate clinical documentation to a new level by enabling real-time visualization of the oral cavity with magnification ranging from 50× to 100×. High-intensity LED illumination ensures shadow-free imaging due to parallel alignment of optical and light axes. These systems facilitate patient education, interdisciplinary consultation, and objective assessment of treatment outcomes.

Dental Operating Microscope

The dental operating microscope provides significant enhancement of visual resolution. Moderate magnification improves resolution up to 20 μm, while high magnification (up to 40×) allows discrimination of structures separated by as little as 5 μm. Integrated video systems, assistant modules, external cameras, monitors, and wireless signal transmission simplify clinical workflows.

Microscope use enlarges fine anatomical details, improves visual perception, and supports ergonomic posture. It enables minimally invasive treatment approaches, enhances cavity and root canal preparation quality, and improves the reliability of obturation.

Magnification levels are adjusted according to clinical tasks, from minimal levels for caries treatment to maximal levels for endodontic procedures. Coaxial shadow-free illumination ensures optimal visualization of difficult-to-access areas. Orange filters may be used to delay composite polymerization.

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Proper ergonomic principles must be observed: the clinician's back remains straight, light is directed toward the dental mirror and reflected onto the operative field, and patient positioning is determined by microscope configuration rather than vice versa.

Dental Photography and Macrophotography

The integration of digital dental photography significantly improves clinical documentation, patient motivation, quality control, and educational processes. Comparative analysis of pre- and post-treatment images facilitates outcome evaluation, error analysis, and treatment planning assessment.

High-quality dental macrophotography requires DSLR or mirrorless cameras equipped with macro lenses and ring flashes. Compact cameras are unsuitable due to insufficient focal length, optical limitations, and sensor size.

Macro lenses with focal lengths between 90 and 105 mm are optimal for dental photography, allowing 1:1 magnification with minimal distortion. Shorter focal lengths increase optical distortion and fogging risks, while longer focal lengths (>120 mm) reduce image depth and exceed flash illumination capabilities.

Recommended macro settings include manual mode, aperture f/22, shutter speed 1/125 s, ISO 100, focal length 100 mm, and 1:1 magnification. Handheld shooting with point autofocus is sufficient without tripod use.

Recommendations for the Use of Optical Systems in Dentistry

- For dental hygienists and periodontists, binocular loupes with 1.5–2.5× magnification are recommended.
- Restorative and prosthetic procedures benefit from magnification levels of 2.0–3.0×.
- Endodontic treatment requires magnification ranging from 3× to 6×.
- Monocular and visor-type loupes are limited to diagnostic applications due to insufficient ergonomics.

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- Intraoral cameras are particularly useful for distal regions and root canal orifices.
- Dental microscopes enable precise caries removal, detection of accessory canals, perforation repair, and retrieval of fractured instruments.
- Dental macrophotography is ideal for case evaluation, interdisciplinary consultations, and documentation outside patient presence.

Conclusion

Visualization using monocular and binocular loupes, intraoral video cameras, dental microscopes, and digital dental macrophotography significantly enhances the quality of dental care, diagnostic accuracy, procedural precision, and occupational safety of dental professionals.

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