

1

The Dental Operating Microscope

Frank Setzer

KEY CONCEPTS

- Parts and functions of the dental operating microscope.
- Advancements in dental microscopy.
- Applications of the dental operating microscope in endodontic microsurgery.
- Individual adaptation of the dental operating microscope (parfocaling).

Endodontic therapy is performed in a naturally dark and confined working space. Operating microscopes were introduced into Endodontics in the early 1990s, and then into endodontic specialty programs in the United States. Since then, operating microscopes have become widely accepted by endodontists and are also increasingly being used by other specialists. The American Association of Endodontists made teaching the operating microscope a required standard for postgraduate endodontic education in 1998. The standard now requires the instruction in using magnification devices “beyond the scope of head worn magnification devices”, at an in-depth level, which is the highest of the levels of knowledge described by CODA.

Higher magnification was demonstrated to significantly increase the successful outcome of endodontic surgery. Both the operating microscope and endoscope provide appropriate magnification and illumination that is required to perform surgical and non-surgical endodontic procedures with high success rates. Moreover, from an ergonomic perspective, a microscope can allow the clinician to maintain an upright position, which can help avoid long-term back and neck problems that may range from general discomfort to disability (see Chapter 22).

1.1 Benefits of the Operating Microscope

Loupes and microscopes offer different ranges of magnification (Figure 1.1). An increase in magnification decreases the focal depth. Wearing loupes, especially at magnifications higher than $\times 4$, requires the practitioner to stay in a narrow range from the object to stay in focus. In contrast, even at high magnifications, a microscope remains stable and the practitioner can work in an upright and ergonomically non-stressful position. Moreover, microscope use reduces strain on eye muscles, fatigue, and soreness compared to loupes. Through a microscope the light reaching the left and right eyes appears to be essentially parallel, achieving the effect of far distance observation (Figure 1.2) and avoiding short accommodation stress as with the naked eye. Binoculars of loupes and thus the viewing direction are convergent, resulting in similar eye strain. In addition, microscopes provide imaging virtually free of shadows, allowing excellent image quality for clinical operations and documentation.

1.2 Key Features of Operating Microscopes

Basic components of an operating microscope are binoculars, microscope body with magnification and fine focus adjustments, and a light source (Figure 1.3). Depending on usage and preferences of the practitioner, a microscope can be further configured to individual specifications. For non-surgical and surgical endodontics, different magnification ranges are required (Table 1.1). In addition, surgical procedures will require more angulations to view resected root

2 | *Microsurgery in Endodontics*

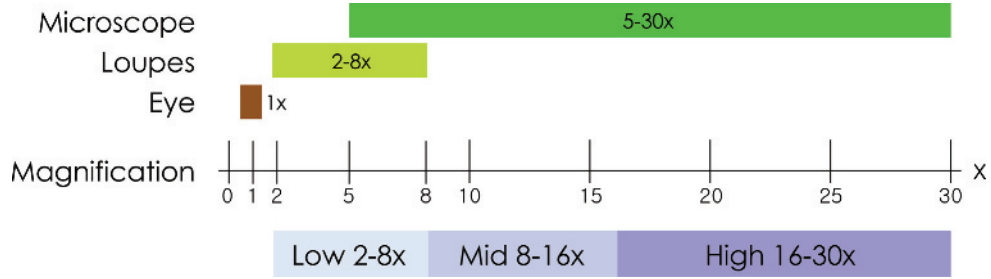


Figure 1.1 Comparison of magnification ranges: loupes versus microscopes.

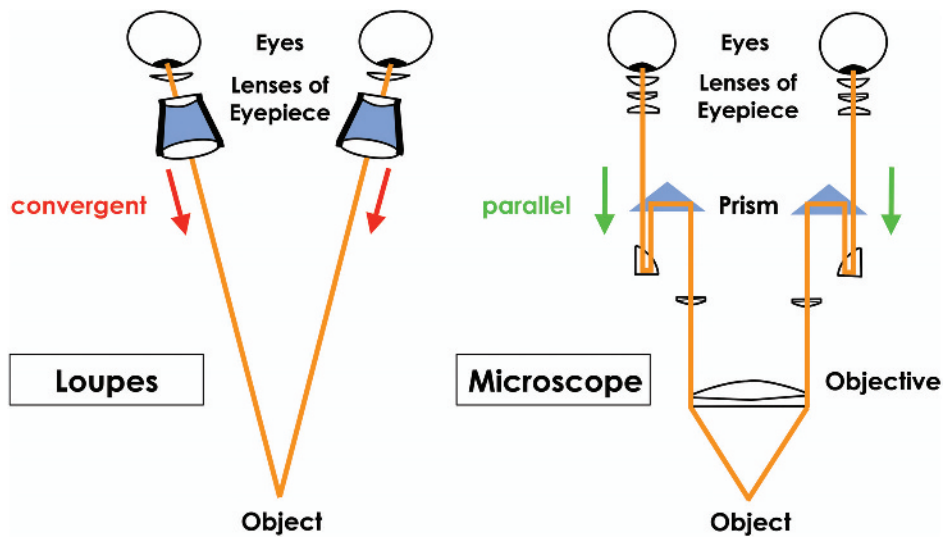


Figure 1.2 Comparison of ocular angles and viewing directions of loupes and microscope.

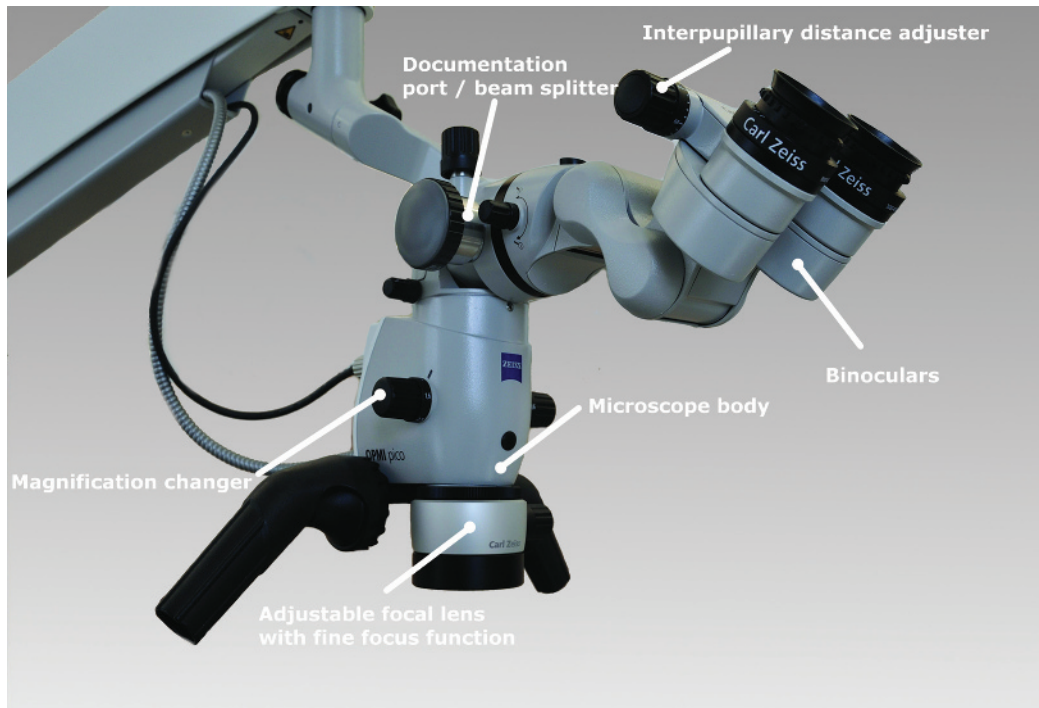


Figure 1.3 Key microscope features (Penn Dental Endodontic Clinic).

Table 1.1 Recommended magnification ranges for different stages of non-surgical and surgical endodontic treatment.

Non-surgical Endodontics	Surgical Endodontics
Low Magnification ~ ×5–8×	
–	Orientation Inspection of surgical site Initial osteotomy Ultrasonic tip alignment Suturing (6.0+) Suture removal
Mid Magnification ~ ×8–×16	
Access Orifice identification Fracture identification Obturation	Hemostasis Tissue removal Root tip identification Root tip resection Root surface inspection Root end preparation Root end filling Root amputation
High Magnification ~ ×16–×30	
Orifice identification Fracture identification Calcified canal location Identification of fine anatomical details Documentation	Root surface inspection Root end preparation inspection Root end filling inspection Identification of fine anatomical details Documentation

surfaces and other anatomical details. At a minimum, a microscope being used for surgical endodontics should be equipped with 180°-tiltable binoculars to address the angulation requirements and an eyepiece with a reticle. A reticle is a set of fine lines that provide proper centering on the object in focus and allows for individual calibration (parfocaling) of the microscope, most commonly in the shape of cross-hairs or concentric rings.

1.3 Customizing a Microscope

Microscopes are available as floor-standing, wall- or ceiling-mounted units, depending on personal preferences and possible locations in the operatory. Modern microscope innovations allow for upgrades or modifications of standard microscopes. For example, in the past, a microscope was delivered with a fixed focal distance, typically 200 mm, 250 mm, or 300 mm, depending on the height of the practitioner and his or her most comfortable and appropriate working position. However, top of the line microscopes today include a variable focal distance that can be adjusted to practitioner and patient, often in conjunction with electrical

zoom and fine focus options that allow smooth and step-less adjustments of both magnification and focus. Recently, mechanical focal distance adjusters were introduced to upgrade microscopes with a fixed focal distance (Figure 1.4).

Optional ergonomic upgrades allow a left/right swivel of the main body of the microscope. This will allow the practitioner to tilt the microscope in a vertical angulation without changing the horizontal level of the eyepieces. In particular, for endodontic surgery, this is a valuable feature to observe root tips and resected root surfaces in the posterior arches. Other major potential upgrades include extendable (foldable) binoculars for better visualization and ergonomics (Figure 1.3), magnetic arrest functions (clutch) for increased stability, as well as different light sources and documentation options, which are described in greater detail in Figure 1.5).

1.3.1 Light Source

Halogen lighting was the first dental microscope light source introduced. It is still available for standard applications and basic microscopes and displays a yellowish hue. Xenon and the more recent LED light

4 | *Microsurgery in Endodontics*



Figure 1.4 Variable focal distance adjuster (ZEISS Varioskop®; Penn Dental Endodontic Clinic).

sources were developed to deploy better illumination to the operating field. All three light sources differ from each other in light intensity, peak wavelengths, color temperature, heat emission, and lifetime.

Xenon light sources appear almost as natural as daylight while providing the highest light intensity. This ensures the best illumination for fine anatomical details and allows shorter documentation exposure times, which will provide sharper images.

LED light sources are similar to xenon in color temperature and appear close to natural daylight. In comparison to xenon and halogen the heat emission from LED radiates from the back of the light source, resulting in a greatly reduced temperature surrounding the microscope. Table 1.2 provides an overview of the light spectra, appearance, color temperatures, intensities, and average lifetimes of the three light sources. Most microscopes provide additional orange

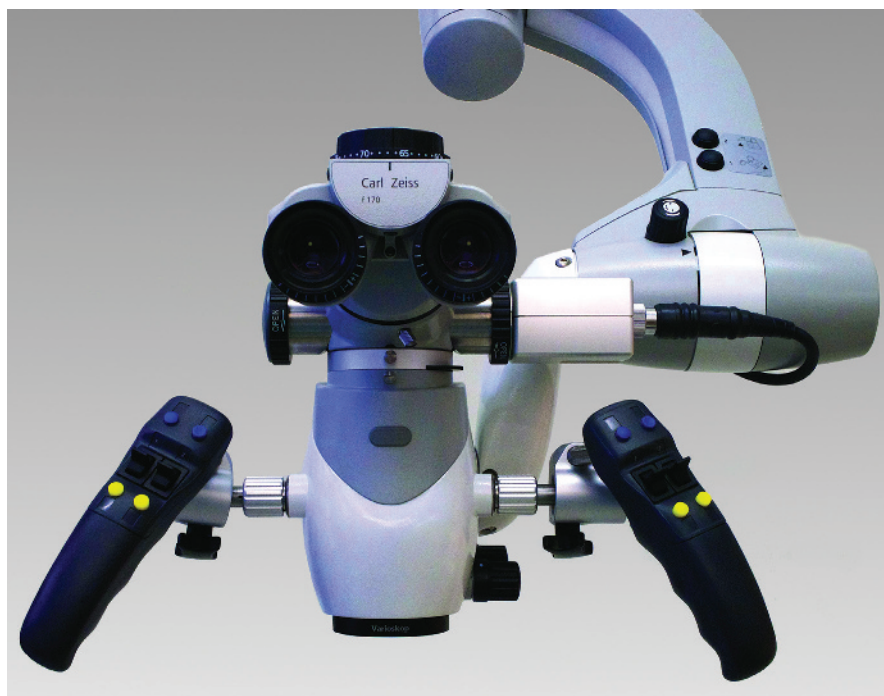


Figure 1.5 Top of the line microscope with electrical zoom, fine focus, and magnetic arrest functions, 3-chip HD video camera (TRIO 610) attached to right documentation port (ZEISS PROergo; Penn Dental Endodontic Clinic, Surgical Suite).

Table 1.2 Comparison of microscope light sources.

	Xenon	LED	Halogen
Light spectrum range and peak(s)	Homogenous spectrum from 400 to 700 nm	Green part of emission spectrum under represented Peaks: 450 nm and 550 nm	Peak: 600–700 nm
Appearance	Like daylight	Comparable to xenon	Yellowish hue
Color temperature	5500 K	5700 K	3300 K
Intensity at 250 mm focal distance	200 000 lux	85 000 lux	85 000 lux
Average lifetime	500 h	70 000 h	50 h

and green filters for restorative work or surgical procedures with increased blood flow. Recent developments include depolarization and daylight UV filters, as well as fluorescence for caries detection.

1.3.2 Documentation

Good documentation is necessary for legal purposes, referral reports, publications, and/or presentations. Still photography can be provided by using a digital SLR camera connected to the beam splitter of the microscope. However, new generation digital mirrorless cameras have demonstrated advantages compared to DSLRs. A beam splitter will divert approximately 20% of the available light intensity to still photography or a video camera. Various options are available for the acquisition of the images, both commercially or customized. For video documentation, options include internal or external cameras of different quality and resolutions. Simpler systems include integrated one-chip cameras that provide simple live streaming and/or recording capabilities. Other modern one-chip options include microchips that allow smart recording to an external, shared network, as well as direct recording to local mass storage devices. Video options are available that record a continuous loop of 30 seconds, providing the option of actually starting a recording in the immediate past, enabling incidences to be documented even after they took place. Current commercial recording qualities range from HD-ready 720p to full HD 1080p resolutions. Full HD 1080p recording combined with three chip cameras are available for the highest quality documentation for publication and presentation purposes.

The latest technology leap included chair-side three-dimensional observation, for both practitioner and co-observers. This technology has so far largely been used for conference settings, using either a shutter or polarized glasses technique, to live-stream sur-

gical procedures. First generation consumer products have been made available recently.

1.3.3 Individual Microscope Adjustment (Parfocaling)

Microscopes are designed to be adjusted to different eye sights to guarantee perfect vision and to avoid fatigue. It is important to understand that depending on the fatigue state of the eyes, e.g., after an entire day of work, parfocaling may lead to slightly different results than when the eyes are rested. It may be necessary to readjust over the course of an intense work period.

First, the practitioner must determine the dominant or leading eye, which predominately adjusts the vision. Several techniques exist, two examples of which are given below.

1. Superimposition technique. The practitioner chooses a distant object, e.g., a street sign. Simultaneously, a near object, e.g., a pencil held with an extended arm, is superimposed over this distant object. Then one eye is closed, with the other one kept open. If the non-dominant eye is closed and the dominant eye is open, the near object will stay centered on the distant object, but it will move sideways if the non-dominant eye is open and the dominant eye is closed.
2. Paper technique. Focusing on a hole in a sheet of paper with both eyes open and then very slowly moving it towards the eyes will result with the hole ending at the dominant eye.

If glasses are worn, the eyecups must be screwed in completely. If an operator wears corrective glasses during the procedures, the parfocaling process must be carried out with the glasses. The eyepiece with the reticle has to be set to the dominant side. Both diopter settings should be moved to the extreme positive setting (Figure 1.6). The microscope should be set to the lowest magnification. This will ease the parfocaling

6 | *Microsurgery in Endodontics*

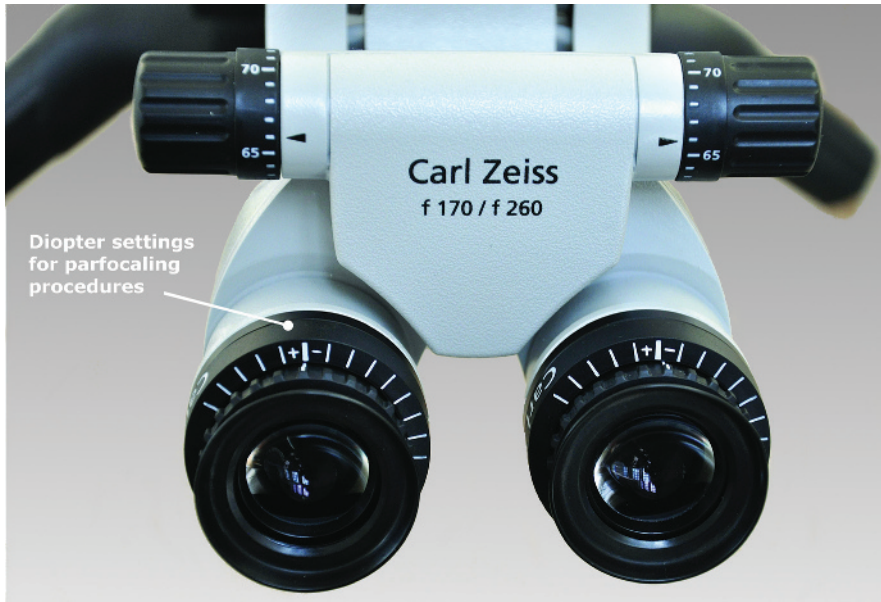


Figure 1.6 Binoculars with diopters for parfocusing procedure (Penn Dental Endodontic Clinic).

procedure for inexperienced practitioners. Individuals with advanced microscope training may adjust the diopter settings at the highest magnification levels.

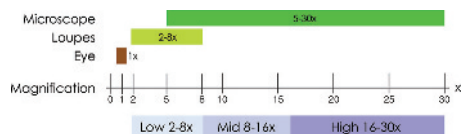
Starting with the dominant eye, the practitioner needs to find the diopter setting where the reticle is clearly focused. During this procedure, the non-dominant eye remains closed. Next, a flat, non-reflecting object, e.g., a business card, is placed under the microscope. Without changing the diopter setting or any of the focusing knobs or buttons, the micro-

scope should be placed at the appropriate (vertical) focal distance to see a focused image only through the dominant eyepiece. The magnification is then changed to the highest setting. To adjust for changes in focal distance, minor adjustments with the fine focus function can be made. Neither the vertical distance nor the diopter settings are changed at this stage. The microscope is now calibrated to the dominant eye throughout the entire magnification range.

The non-dominant side will then be adjusted to the dominant side. Looking through the non-dominant

Table 1.3 Quick-step guide to parfocusing a microscope.

Step	Magnification Setting	Technique
Determine dominant eye	–	Use near object over distant object superimposition technique.
Adjust dominant eye	–	Place eyepiece with reticle into binoculars on dominant eye side.
	–	Adjust diopter settings on eyepiece until all reticle lines are clearly focused.
	Low	Focus on object through the microscope after initial adjustment of focal distance.
Adjust non-dominant eye	High	Use fine tuning to perfect focus.
	High	Adjust diopter settings on eyepiece until object is focused.
	Variable	Adjust interpupillary distance settings until a single image is clearly visible.



eyepiece only, the diopter settings are turned slowly while looking at the object under the microscope. When the object is focused, the non-dominant side is calibrated. No changes to the dominant side must be made.

Last is the interpupillary distance. The adjustment knob for the interpupillary distance is set to the lowest setting and then slowly turned until one perfectly clear

single picture with three-dimensional qualities is visible through the microscope. Table 1.3 is a quick guide of the individual parfocusing steps. Please note that most individual's dominant eye is the right eye and that therefore video outputs are frequently attached to the right eyepiece. This means that the video feed then matches exactly the right eyepiece and provides a two-dimensional monitor image from the dominant eye.

Suggested Readings

- AAE Special Committee to Develop a Microscope Position Paper. AAE Position Statement. Use of microscopes and other magnification techniques. *J Endod* 2012;38:1153–1155.
- Carr G. Microscopes in endodontics. *Calif Dent Assoc J* 1992;11:55–61.
- Clark DJ, Sheets CG, Paquette JM. Definitive diagnosis of early enamel and dentin cracks based on microscopic evaluation. *J Esthet Restor Dent* 2003;15:391–401.
- Kersten DD, Mines P, Sweet M. Use of the microscope in endodontics: results of a questionnaire. *J Endod* 2008;34:804–807.
- Leknius C, Geissberger M. The effect of magnification on the performance of fixed prosthodontic procedures. *J Calif Dent Assoc* 1995;23:66–70.
- Mamoun JS. A rationale for the use of high-powered magnification or microscopes in general dentistry. *Gen Dent* 2009;57:18–26.
- Mines P, Loushine RJ, West LA, Liewehr FR, Zadinsky JR. Use of the microscope in endodontics: a report based on a questionnaire. *J Endod* 1999;25:755–758.
- Monea M, Hantoiu T, Stoica A, Sita D, Sitaru A. The impact of operating microscope on the outcome of endodontic treatment performed by postgraduate students. *Eur Sci J* 2015;305–311.
- Pecora G, Andreana S. Use of dental operation microscope in endodontic surgery. *Oral Surg Oral Med Oral Pathol* 1993;75:751–758.
- Rubinstein RA, Kim S. Short-term observation of the results of endodontic surgery with the use of a surgical operation microscope and Super-EBA as root-end filling material. *J Endod* 1999:43–48.
- Setzer FC. The dental operating microscope in endodontics. *AAE Colleagues for Excellence* 2016;2:1–8.
- Setzer FC, Kohli M, Shah S, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature – Part 2: Comparison of endodontic microsurgical techniques with and without the use of higher magnification. *J Endod* 2012;38:1–10.
- Tibbets LS, Shanelec DA. Periodontal microsurgery. *Dent Clin North Am* 1998;42:339–359.

