

# The Surgical Operating Microscope and Micro-Instrumentation in Endodontic Therapy

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## Introduction

Enabling the dental clinician to clearly illuminate and visualize difficult procedures, the introduction of the surgical operating microscope (SOM) and micro-instrumentation is among the most important recent developments in endodontics. Although employment of the SOM began with otologists over forty years ago, dental use of the SOM has only recently gained support from endodontists and other dental specialists. This increased interest in microscopy is attributable to the SOM's capacity to assist in performing both simple and complex procedures with greater accuracy.

## Technical aspects of the SOM

The typical SOM head consists of three principal parts: body tube optics, eyepiece, and objective lens (Figure 1). Working together, these pieces magnify small objects within the surgical area by powers of approximately 5, 8, and 12. This three-step system is available in an upgraded five-step version that adds about 4 and 16 powers. Changing the eyepiece from 10 power to 12.5 power increases overall magnification by 25%. In addition motorized zoom systems are available that may add both versatility and convenience. Typically, in the dental setting, the 200mm objective lens provides the correct working distance.

The SOM is adaptable to various office environments inasmuch as the head portion of the microscope, supported by a counterbalanced arm, is attachable to a floor stand, wall mount, or ceiling mount (Figure 2). Various options enhance the utility of the SOM even further, and many SOM systems allow for modular expansion and upgrading to meet changing needs. For example, a multi-axial binocular observer system allows an assistant or second operator to view the procedure. An additional option, the inclinable binocular, allows the adjustment of the binoculars for added flexibility and operator comfort during procedures (Figure 3). Illumination is a key feature of the SOM, allowing procedures to be viewed with a high level of clarity and increased depth of focus. A choice of fiberoptic or integral halogen light sources allows current SOM's to deliver approximately 20,000 foot candles of light to the operating field. Optional xenon fiber optic light sources offer about 50,000 candle power.

Documentation systems for the SOM require the addition of a beam splitter to allow for the attachment of a large selection of video cameras and/ or 35mm photographic cameras for high-resolution imaging (Figure 4). Video monitors, video recorders, computer disk storage and retrieval systems, and video printers are also available. The video data created by the video printer can be stored in the printer's

internal micro-computer for later optimization and printing, or printed at the time of capture for viewing in about one minute. Video images can also be captured and stored on computer disk as a file, using a video capture board or USB2 software. SOM-created images can be sent by modem to other computers for a distant viewing and analysis.

### **Uses of the SOM in Dentistry**

The introduction of the SOM has revolutionized both non-surgical and surgical endodontics and will likely have a significant impact in the other fields of dentistry. Outlined below are various applications of the SOM in treating routine and complex cases, retreatments, and especially surgical procedures.

**Routine Cases:** The SOM is effective in examining the pulp chamber and root canal system. For example, during the search for canals in order to assess the completeness of cleansing and the existence of fractures, the SOM helps to determine whether the chamber roof has been adequately removed under a full crown, especially if calcification has narrowed the vertical height of the chamber in a crown-root direction. Before the advent of the SOM, removal of the roof of the chamber could more easily result in an inadvertent perforation of the chamber floor due to lack of visualization. Also, the enhanced visualization enables more efficient biomechanical instrumentation by reducing fatigue and eye strain. The eyeglass-type loops available for improved magnification are also helpful to this end, but suffer from lack of intense focused lighting, and less depth of focus and offer only one power of magnification per pair.

**Complex Cases:** Difficult endodontic cases may consist of: (1) calcified root canal and/or chamber systems; (2) internal resorptive lesions with or without external complications; (3) crown and root fractures; (4) caries; and (5) cases with limited or restricted access.

1. Treatment of calcified teeth pose difficult challenges because of the obliteration of the coronal and radicular pulp. Although these calcifications occur in the healthy uninfamed pulp, they tend to increase in dimension and frequency with irritation and age.

The SOM allows the operator to discern differences in the color of primary and other dentin types, thereby facilitating location of the root canal orifices.

An explorer locating the softer dentin usually found at the orifice in a calcified chamber system can actually gouge the dentin at different depths, depending upon the density of the dentin. However, the SOM allows the operator to see well-lighted detail while the dentin is explored. Thus, at times, it becomes instantly apparent when an explorer is inserted into a necrotic root canal orifice because an exudate becomes visible, marking the site as the correct location for further instrumentation. Further, this visualization allows real-time inspection of each explored site to help determine whether a perforation of the chamber floor is made before instrumentation causes extensive erroneous enlargement.

Removal of overlying dentin can be safely and precisely accomplished with direct vision through the SOM, using a high-speed handpiece or ultrasonic tips. Actual penetration of the root to locate buried root canal systems becomes visually enhanced because of the often unobstructed real-time view through the dental mirror provided by the SOM while one is operating the handpiece.

2. Among the most difficult endodontic lesions to treat are the pathologic external root resorption and the rarer progressive type of internal resorption. When the resorptive lesion is in the middle or coronal third of the root canal system, it is often possible to view and better gauge the prognosis of these teeth without relying solely on radiographic interpretation (Figure 5).<sup>1</sup> In this regard, calcium hydroxide can be applied directly to the lesion, and prognosis for other treatment modalities, such as root extrusion, can be made.
3. As noted above, visualizing crown and root fractures is a major advantage provided by the SOM. Many teeth that have fractured restorations and/or fractured crowns and root canal systems undergo endodontic therapy. Fractured amalgams and tooth structure can be viewed and documented with excellent results using both 35mm and video technology (Figure 6). The video images can be saved either as a video print, saved to disc on any computer equipped with a video-capture board, or displayed to the patient instantly via the freeze-frame mode. This level of documentation is a valuable patient educational tool. Additionally, these images, once transcribed to hard copy, can help communicate the exact location and extent of these fractures to other treating dentists.

Ordinarily, the size and extent of a fracture determines the prognosis for a tooth. Specifically, for example, a dark fracture that extends from the crown cavo-surface margin of a molar into the distal root and down the root to the apical third would more likely fail than a fracture that extends only to the orifice or slightly beyond. Methylene blue dye will aid in the visualization of fractures.

4. Caries removal, especially under full crown restorations, is more accurate and complete because the carious defect can be viewed while the dental handpiece is actually being used. If sealing of a carious perforation is attempted, the SOM is helpful in the preparation of the site and helps visualize the application of appropriate filling material.
5. Locating canals and examining the chamber and root canal system for fractures in difficult-access situations is also made easier using the SOM. For instance, third molars and distally tipped second molars present fewer visibility problems with the intense light of the SOM (Figure 7). Accordingly, minor color changes in the dentin are more easily discernible, providing clues for locating calcified canals and facilitating caries removal.

Retreatments: Endodontic retreatments pose some of the most difficult challenges to the clinician. The nonsurgical retreatment of endodontic failures is the preferred treatment when feasible.<sup>4</sup> When it is evident that retreatment is necessary, whether due to radiographic periapical pathosis or discomfort or for prosthetic reasons, the SOM again enhances visualization. Inadequate cleansing and obturation are principal contributors to endodontic failure.<sup>5</sup> The exquisite visibility afforded by the illumination and magnification of the SOM aids in the accurate removal of the material in the chamber without undue risk of perforation. Thus, it becomes a simple matter to remove most cements, amalgam, and cast metallic cores because the material can be viewed almost simultaneously with removal. In these cases, the orifices of the canals can be accurately identified and removal of the canal filling material can be accomplished using a solvent (or heat) for gutta percha and ultrasonics for nonsoluble cements, silver cones, and broken instruments. Ultrasonic instrumentation is a valuable tool in removing the cements frequently used in endodontic therapy performed overseas. Ultrasonic retro-prep tips and files, can often remove non-soluble cements quickly and accurately, thereby greatly reducing the chances of perforation associated with high- and low-speed dental handpiece burs (Figures 8 and 9). This procedure can be monitored with the SOM at critical intervals to further enhance control of the removal process.

Separated endodontic instruments in the root canal system may result in endodontic failure. With respect to the removal of these iatrogenic problems, the SOM is valuable for monitoring during the ongoing process. Once the canal is widened with ultrasonic Carr tips, the fractured instrument blocking the canal can often be visualized. With the use of ultrasonic Carr tips, the instrument can be vibrated free if in the coronal one-third of the root, or similarly freed with ultrasonic file tips if in the middle or apical third (Figures 10,11,12).<sup>6</sup> With the SOM, this process can be monitored at critical points to ensure accurate placement of the tips or files. Occasional use of the Masserann and Roydent trephines and pinch-pressure devices may prove successful, but their large size make them impractical for many intra-radicular situations (Figure 13). Similarly, the SOM is useful in removing silver cones which can be seen and retrieved more easily. Even silver cones lodged in the middle and apical third can be manipulated with retrieval instruments and more accurately vibrated ultrasonically with the increased visibility provided by the SOM.

Intra-radicular post removal has been a difficult treatment issue for anyone attempting nonsurgical retreatment of an endodontic failure or post fracture. Although no general agreement among endodontists about the best methods of post removal exists, ultrasonics play a significant role.<sup>7</sup> With the SOM, placement of the ultrasonic Carr post-removal tips on the non-cast and cast posts becomes more precise, and the vibratory forces are better directed until the post loosens in its preparation. Also, removal of the cement and/or composite or glass ionomer resins in the chamber around the post becomes easier. Most cemented non-cast posts can be removed in under twenty minutes using the ultrasonic and the SOM.

**Surgical Cases:** The surgical approach is necessary when orthograde endodontic treatment is impossible or ineffective in resolving endodontic pathosis.<sup>8</sup> The SOM is especially suited to endodontic surgery because of its ability to magnify and illuminate the surgical site. Use of microsurgical scalpels (CK-2), when directed under the SOM, enables a precise incision (Figure 14). The initial incision is performed under low power, which affords an overview of the entire surgical area while at the same time lighting the site with much higher intensity than an overhead light or headlamp. Atraumatic flap management can be best accomplished under relatively low magnification, using the microsurgical scalpel to preserve the sulcular epithelium in sulcular incisions and the Ruddle curette to “reverse elevate” the flap. The magnification can then be increased to allow assessment of the osseous tissue. Slight changes in the color of the cortical plate can help to locate the sites of the periapical pathosis. Curettage of the periapical tissue is then accomplished, and the crypt and root can be visualized.

One can use the Impact Air high-speed handpiece with its specially designed 45 degree-angled head and water-only delivery (Figure 15) to bevel the root tip. This handpiece virtually eliminates the possibility of an air embolism because it does not force air into tissue spaces. Finally, in order to examine the exposed root for fractures, a small applicator brush can be used to apply methylene blue stain (Figure 16).

Retro-preparation of the root apex or large lateral canals can then be performed by using the ultrasonic Carr retroprep tips. In the author’s opinion, these tips afford much better handling characteristics than the mini-headpieces now in general use for the low-speed handpiece. The Carr tips allow a true Class I preparation down the long axis of the root and accurate preparation down the long axis of the root and accurate preparation of the isthmus between canal apices, if necessary. Other advantages of the retrotips include minimum root bevel and minimum bone removal because these tips are about one-tenth the size of the traditional mini-headpieces. The SOM allows detailed examination of the apical micro-preparation during the entire procedure.

After the apical retroprep is performed, a thorough examination can be made using the extremely high quality reflective surfaces of small sapphire mirrors (Figure 17). Retro views of the apical preparation are necessary to ensure correct angulation of the retrotips and to ensure that at least three millimeters of clean dentin are prepared for retrofilling. Tags of gutta percha, cement, and involved dentin can be visualized and removed even on the buccal or facial prep wall. Retrofilling of the prep can then be accomplished using a series of micro-condensers, burnishers, and carvers (Figures 18 and 19).

The spectacular clarity of the SOM provides a definite benefit in the placement of bone augmentation material, guided tissue regeneration procedures, and routine suturing. Because suturing is critical to the success of these membrane

placements and routine surgery, the SOM's visualization and ability to provide easy documentation in both still and video formats are valuable resources.<sup>9</sup> Even in routine endodontic surgery, where increased accuracy of needle placement and better tissue edge approximation for primary wound healing are critical, the SOM is extremely effective.

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