The Use of Magnification in Endodontic Therapy: The Operating Microscope

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Clinicians have recognized that the use of magnification can improve the performance of dental procedures. Of the various magnification systems available, loupes have been the most popular, yet their magnification is limited. This article reviews and describes the function and clinical application of the surgical operating microscope (SOM), emphasizing its utilization in endodontic treatment. Several cases are presented to document the clinical procedure and to illustrate the difference between operative procedures performed without magnification and those completed using the SOM with micromirrors.

Telescopes or loupes have been readily available in a variety of configurations and magnifications. With the aid of a fiberoptic headlamp system, light can be projected in the line of sight to prevent the creation of shadows in the surgical field and render optimal visualization of the treatment site. However, the magnification of loupes is limited (2.5× to 6.0×) and their optics are convergent, which creates eye strain and fatigue. In order to address the limitations present in these devices, clinicians adopted new techniques and technologies.

Otologists were the first medical specialists to utilize the operating microscope in a clinical environment. In 1921, Nylen performed a surgical procedure with the operating microscope.[1] When Jannetta performed a procedure called microvascular decompression to treat trigeminal neuralgia, the event became the subject of controversy (to use or not to use the microscope) in the neurosurgical community.[2] The surgical operating microscope (SOM) has been recently introduced in dentistry, specifically in endodontics, where increased magnification and illumination have resulted in improved technical accuracy and performance.[3]

The Surgical Operating Microscope

The surgical operating microscope consists of three primary components — the supporting structure, the body of the microscope, and the light source.

The Supporting Structure

It is essential that the microscope be stable while in operation, yet remain maneuverable with ease and exceptional precision, particularly when used at high power. The supporting structure can be mounted on the floor, ceiling, or

Figure 1. Clinical application of the microscope. The operator and assistant are in comfortable positions.

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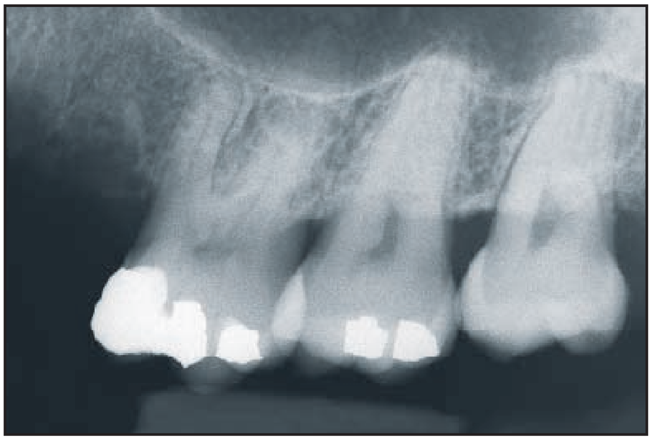

Figure 2. The preoperative radiograph does not reveal any complications in the root canal anatomy.

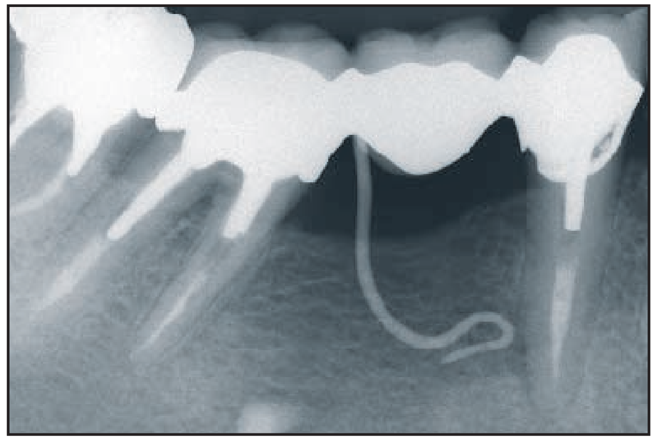

Figure 4. Case 1. Preoperative radiograph tracing a fistula with a gutta-percha point. A lateral lesion is suspected.

wall. As the distance between the fixation point and the body of the microscope is decreased, the stability of the setup is increased. In clinical settings with high ceilings or distant walls, the floor mount is preferable. Careful attention should be given to the precise setting of the arms. The built-in springs should be tightened according to the weight of the body of the microscope to establish perfect balance in any position. This permits precise visualization and renders the fine focus unnecessary in the majority of clinical circumstances.

Body of the Microscope

Eyepieces are used in the overall magnification. They are available in various powers, ranging from 6.3× to 20×; the two most commonly used are 10× and 12.5×. The end of each eyepiece has a rubber cup that can be lowered for clinicians who wear glasses. Eyepieces also have adjustable diopter settings.

Figure 3. Microscopic view of the pulp chamber reveals 3 distinct orifices in the mesiobuccal root. Palatal orifice and one half of distobuccal orifice are not revealed.

The binoculars contain the eyepieces and allow the adjustment of the interpupillary distance; they are aligned manually or with a small knob until the two divergent circles of light combine to effect a single focus. Binoculars are available with straight, inclined, or inclinable tubes. Straight tubes are generally used in otology and are not well suited for dentistry. Inclined or inclinable tubes are preferred to allow the clinician to establish a comfortable working position. Inclined tubes are fixed at a 45° angle to the line of sight of the microscope; inclinable tubes are infinitely adjustable. The microscope is positioned over the patient's mouth, and the binoculars are inclined in such a manner that the head and neck of the operator can be held at an angle where comfort can be sustained throughout the entire procedure (Figure 1). Indirect vision is a characteristic of clinical diagnosis and treatment that is specific to dentistry. In conventional endodontics, it is impossible to examine a root canal with straight line access. With the microscope, use of the mirror is essential and allows multiple angles of vision without moving the body of the microscope.

Magnification changers are available as 3-, 5-, or 6-step manual changers, or a power-zoom changer. They consist of lenses mounted on a turret that is connected to a dial located on the side of the microscope. The magnification is altered by rotating the dial.

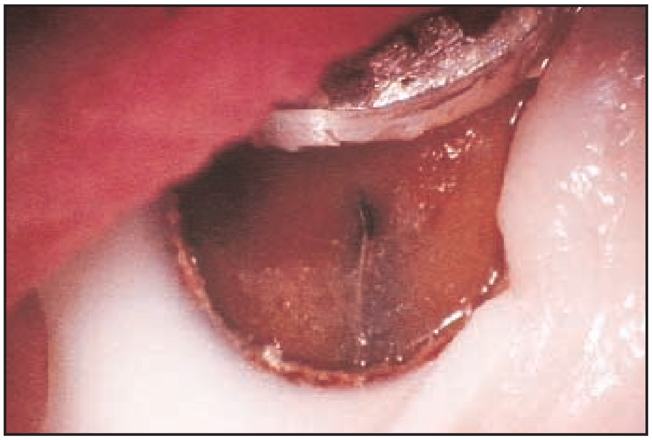

Figure 5. Microscopic examination reveals a crack that does not extend completely to the margin of the restoration.

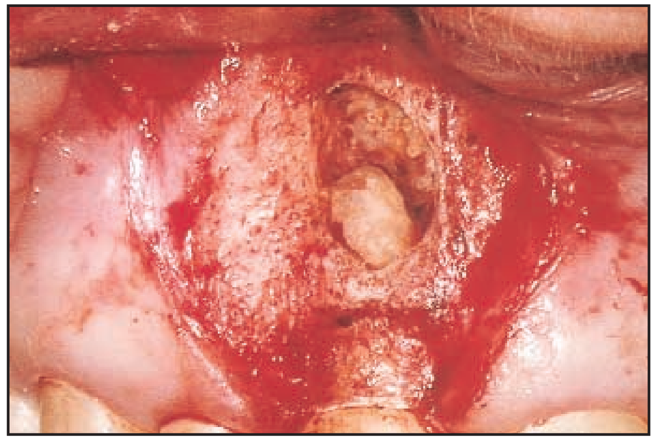

Figure 6. Case 2. View of a surgical site of a maxillary central incisor without magnification.

The objective lens is the final optical element, and its focal length determines the working distance between the microscope and the surgical field. The range of the focal length varies from 100 mm to 400 mm. A 200-mm focal length allows approximately 20 cm of working distance, which is generally adequate for utilization in intraoral procedures.

The total magnification of a microscope[4] is represented by the following formula:

$$TM = (FLT/FLOL) \times EP \times MV$$

TM: Total magnification.

FLT: Focal length of tube.

FLOL: Focal length of objective lengths.

EP: Eyepiece power.

MV: Magnification value.

The range in magnification from 2.5× to 8× is used for an intraoral surgical site. For example, the wide-field view allows a better evaluation of the root position in surgical endodontics. Magnifications in the range of 10× to 16× are used for operating; 90% of the use of the microscope is at this power. The higher magnifications (20× to 30×) are used to examine fine details.

A typical microscope setup should have the following features to be properly equipped for application in dentistry[5]:

- 12.5× eyepiece power.
- 125-mm inclined binoculars.
- 5-step changer, ranging from 4× to 28×.
- 200-mm objective lens.

Surgical operating microscopes possess the additional benefit of Galilean Optics. As opposed to loupes, which have convergent optics, Galilean Optics focus at infinity and send parallel beams of light to each eye. With parallel light, the operator's eyes are at rest, as though looking off into the distance, permitting performance of time-consuming procedures without inducing eye fatigue.

Light Source

The light source is one of the most important features of an operating microscope. For the first time in dentistry, the illumination is coaxial with the line of sight, which

Figure 7. View of the same site at 16× magnification with a micromirror. Three portals of exit can be discerned at the apex.

eliminates the presence of any shadow. The light source is generally powered by a 100- to 150-watt halogen light bulb that is connected to the microscope with a high-efficiency fiberoptic cable. The light passes through a condensing lens, a series of prisms, and then through the objective lens to the surgical site. The intensity of light is controlled by a rheostat.

Accessories

In order to deflect a certain percentage of the light from the eyepiece towards the accessories, a beam splitter can be placed between the binoculars and the magnification changer. The beam is generally split at a 50:50 ratio (ie, half of the light is always available to the operator). A photo or video adapter can be connected to the beam splitter. The video camera is a useful adjunct and serves two additional purposes: it allows the assistants to follow the procedure precisely and assist efficiently, and it can also be used for documentation using video prints or recordings.

Use of the Surgical Operating Microscope in Endodontic Therapy

The surgical operating microscope was introduced to endodontic therapy only a decade ago. At the time, only a few clinicians in the United States and Europe believed in its utility. The SOM has gained wide acceptance during the past 10 years and is now considered to be an important tool in endodontic practice. Since 1997, microscopic techniques in endodontics have been instituted in the curricula of all graduate dental schools in the United States. All graduate students must be proficient in clinical application of the SOM and knowledgeable of all aspects of its usefulness in endodontic therapy.

Diagnosis

The SOM enables the endodontist to assess the marginal integrity of restorations and to detect cracks or fractures. The cracks can be coronal and may be found following the removal of a restoration. Once the tooth has been accessed, cracks can also be detected on the floor of the pulp chamber. For optimal visibility, it is important to control the dryness of the dentin when using the microscope. If the dentin is too dry, the texture appears white and chalky, and the crack will not be visible; if the dentin is too wet, the reflection of water on the surface will mask the crack. To precisely adjust the drying of the dentin surface, the author uses the irrigator (Stropko, EIE Analytic, Orange, CA). It adapts on a 3-way syringe that can be used with any size needle. The average size needle of 25 gauge is suitable for most routine applications; a fine 30-gauge needle is utilized to dry the inside of root canals when using the nonsurgical or surgical approach.

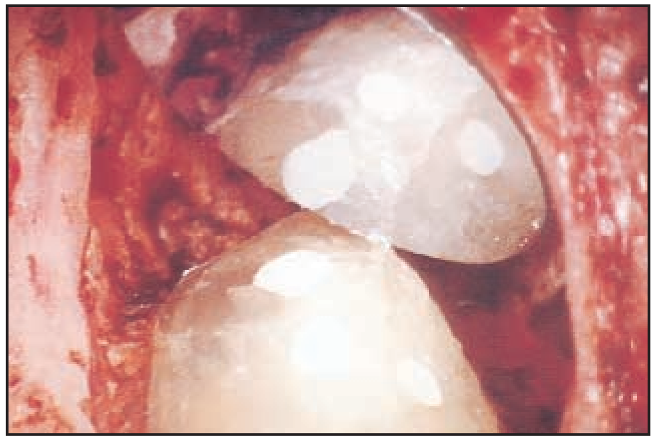

Figure 8. The three apical foramina were prepared with ultrasonic tips and filled with retrofill.

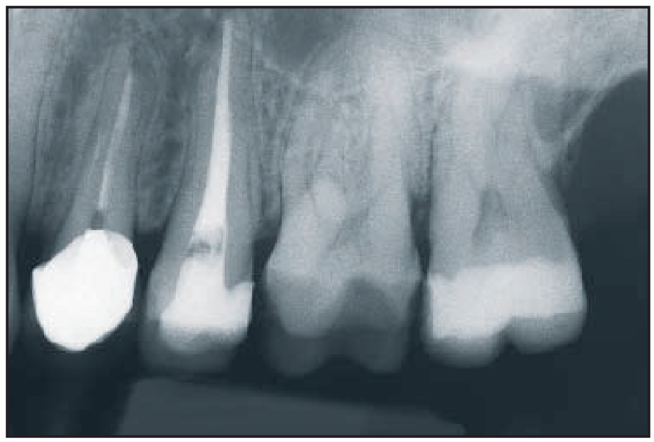

Figure 9. Case 3. Preoperative radiograph of an unsuccessful endodontic surgery and inadequately placed amalgam retrofill.

The SOM is also an efficacious method for detecting radicular cracks. While coronal cracks can often be treated by a well-adapted crown, radicular cracks determine the prognosis of the tooth. Undetected root fractures in large fixed restorations can initiate significant complications. In such cases, the gingiva is carefully retracted, and the root surface is gently dried with the irrigator (Stropko, EIE Analytic, Orange, CA). In numerous instances, the width of the crack is merely that of a hairline

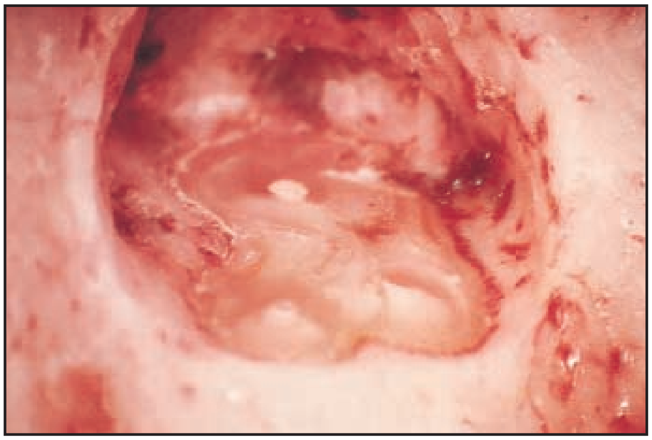

Figure 10. View of a beveled root surface, revealing a more complex anatomy.

Figure 11. Ultrasonic preparation of the 3 canals and the isthmus joining them.

and would go unnoticed without the use of the operating microscope. In addition, utilization of the microscope allows a video print to be recorded and presented to the patient and the referring clinician.

Nonsurgical Endodontics

Accessing the pulp chamber and locating the canals constitute important visual phases of endodontic therapy. Errors at this level will compromise the entire treatment. The SOM identifies calcified canals and additional canals with ease. The initial step mandates complete removal of the roof of the pulp chamber. This procedure is accomplished by using round burs under the microscope in order to create smooth and regular surfaces on the walls and floor of the access cavity. The floor of the pulp chamber can then be carefully explored with a DG 16 explorer. Smaller instruments are used under the microscope to localize the canal orifices. The round LN bur (Dentsply/Maillefer, Tulsa, OK) and ultrasonic tips are used in combination in a brush-cutting action to safely eliminate the secondary dentin overlying the orifices. Pulpstones can be readily detected and eliminated.

One of the advancements in canal location with the operating microscope is the routine identification of the second mesiobuccal canal of maxillary first and second molars (Figures 2 and 3). Clinically, the mesiobuccal root contains a second root canal system[6] that can be identified and treated more than 75% of the time.[7] Histologically, it has been demonstrated that mesiobuccal roots contain 2 systems almost 100% of the time.[8] Therefore, it must be assumed that all maxillary first and second molars have four canals, until proven otherwise. Kulild et al also found that almost 10% of the canals could be detected only with the microscope.[8] The strategy in locating secondary mesiobuccal canals should be applied to all additional canals. One of the determining features is the "dentin map," a fine line on the pulp chamber floor that connects all orifices. The dentin map can be traced and will invariably lead to the locations of the remaining canals.

Retreatment

As fewer teeth are extracted, an increasing number of retreatment cases has been recorded during the past 15 years. Utilization of the SOM in endodontic retreatment has brought significant advantages and has expanded the scope of indications using a nonsurgical approach. Procedures such as bypassing a ledge, removing a broken instrument, or repairing a perforation have become considerably more reliable.

Surgical Endodontics

Surgical endodontics is likely the area of endodontic therapy that has experienced the greatest degree of change during the past decade. Introduction of the SOM and ultrasonic tips for root-end preparation are the two primary reasons for the change. Every step of the surgical procedure benefits from enhanced magnification and illumination. Periapical curettage is facilitated, since bone margins can be scrutinized for completeness of tissue removal. The apicoectomy is performed with a high-speed handpiece (Impact Air 45, EIE Analytic, Orange, CA) perpendicularly to the long axis of the root, which ensures preservation of root length. The resected surface is examined carefully with micromirrors for the presence of an isthmus.

In recent studies, a complete or partial isthmus was found at the 4-mm level of the mesiobuccal root of the maxillary first molar 100% of the time, and a complete isthmus was found 90% of the time at the 3-mm level of the mesial root of the mandibular first molar.[9] Apical preparation is achieved with ultrasonic tips, developed by Carr,[3] and available in shapes to suit all clinical circumstances. For sufficient energy, the tips must be used on piezoelectric units, which allow a conservative preparation in the long access of the canal. The preparation is dried with an irrigator (Stropko, EIE Analytic, Orange, CA) and carefully examined under the microscope at high power, using micromirrors. The cavity is subsequently filled with retrofilling materials (eg, IRM, Dentsply/Caulk, Milford, DE; SuperEBA, Bosworth, Skokie, IL). The margins are finished, and the retrofill is inspected. A video print should be recorded and forwarded to the referring clinician with the definitive radiograph. One recent prospective study demonstrated that the success rates of endodontic surgery performed under the SOM employed the microsurgical technique and the appropriate cement (eg, SuperEBA, Bosworth, Skokie, IL). A success rate of 96.8% with an average healing time of 7.2 months was observed.[10]

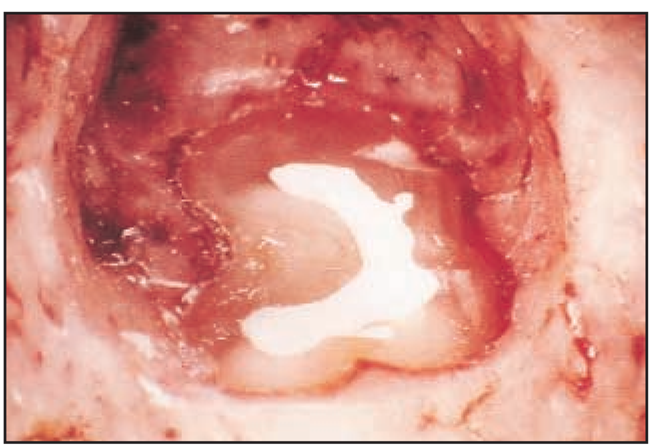

Figure 12. View of the same site obturated with retrofill material.

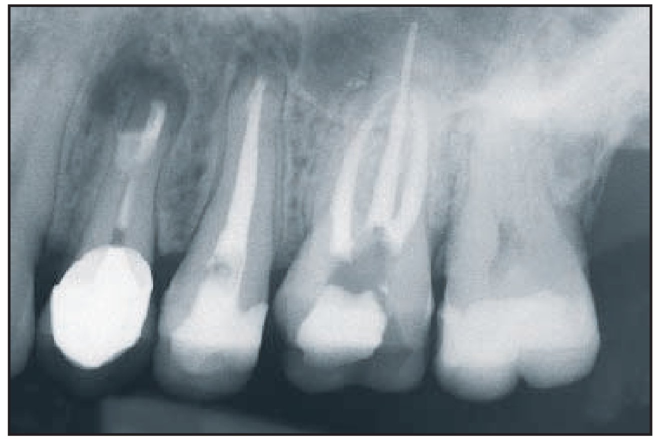

Figure 13. Immediately postoperative radiograph revealing an unusual appearance of the retrofill.

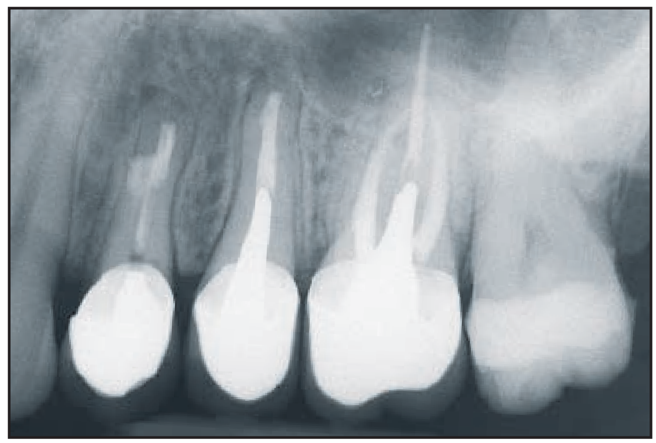

Figure 14. Six-month postoperative radiograph, revealing a complete healing.

Case Presentations

Case 1

A 45-year-old male patient presented with mild symptoms and a sinus tract in the mandibular right quadrant. The first molar had been extracted, and a fixed prosthesis had been used to replace the tooth using the second molar and the second premolar as abutments. The sinus tract was traced with a gutta-percha point, and a radiograph was taken (Figure 4). At the completion of diagnosis, the presence of a lateral lesion was established on the distal aspect of the second premolar at the junction of the middle and apical third of the root, perhaps due to the existence of a lateral canal. The treatment plan was designed as follows: If the bridge required reconstruction, nonsurgical endodontic

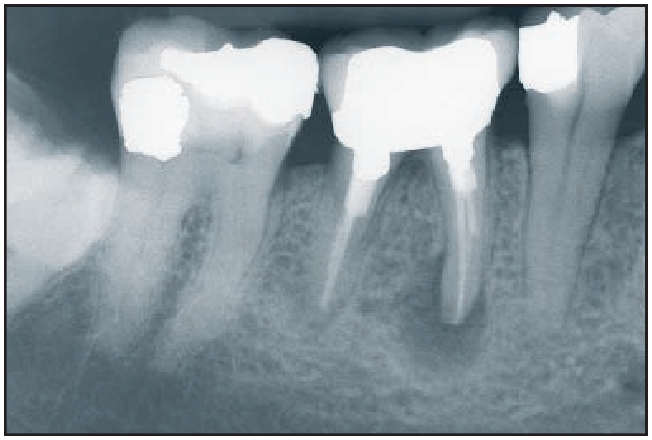

Figure 15. Case 4. Preoperative radiograph of the mandibular left first molar. The treatment of the two mesial canals initially appears to be adequate.

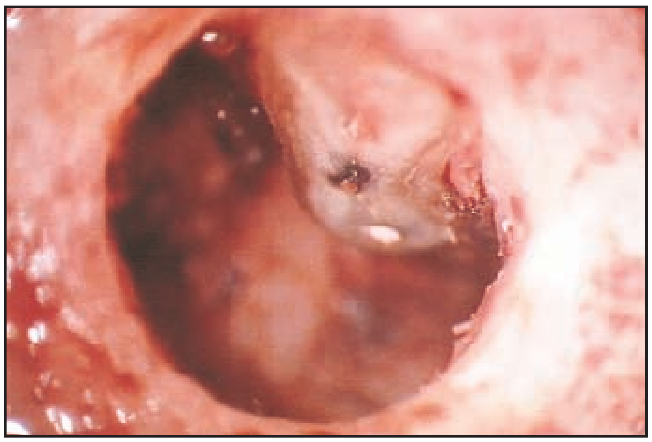

Figure 16. Microscopic examination of the beveled root surface reveals a third untreated canal between the two treated canals.

retreatment would be attempted; if the prosthesis was to be retained, endodontic surgery would be performed.

Upon periodontal probing on the facial aspect of the second premolar, a narrow sulcular defect was detected; however, no crack was visible at the margin of the restoration. The gingiva was retracted, the surface dried, and the microscope was used to enhance visibility. The crack was clearly visible, even though its coronal extension was not complete (Figure 5). Prognosis for tooth survival was deemed to be poor, and no endodontic therapy was scheduled.

Case 2

A 32-year-old female patient presented with a lesion of endodontic origin on the maxillary right central incisor. The tooth had a suitable crown and a post that extended beyond the midroot level. Use of the surgical approach was selected. Prior to magnification, the treatment required appeared to be a straightforward anterior surgery (Figure 6). At high magnification (16×), however, 3 portals of exit were readily discerned (Figure 7). If not treated, each portal could be responsible for the persistence of the lesion. The 3 apical foramina were prepared with the ultrasonic tips and filled (Figure 8).

Case 3

A 42-year-old female patient presented with recurrent symptoms in the region of the maxillary first left premolar. A previous surgery had been performed, but the symptoms were still present. The preoperative radiograph revealed an inadequately placed amalgam retrofill (Figure 9). In view of the previous surgery, the surgical approach was selected to treat the condition. The bevel of the root revealed a more complex anatomy than expected; the premolar had 3 canals and an isthmus joining them (Figure 10). The apical preparation was performed with the ultrasonic tips (Figure 11), and a retrofilling material (IRM, Dentsply/Caulk, Milford, DE) was subsequently placed (Figure 12). The immediate postoperative radiograph revealed an unusual appearance of the retrofill (Figure 13). Six months postoperatively, a radiograph confirmed complete healing at the site of the treatment (Figure 14).

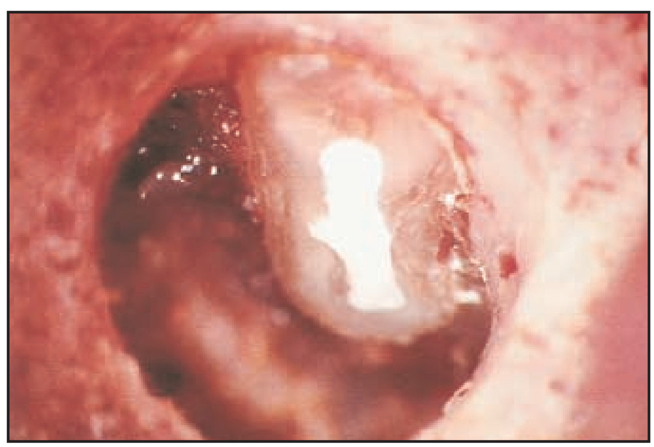

Figure 17. Postoperative view of the 3 canals and the isthmus joining them obturated with retrofill.

Case 4

A 55-year-old female patient presented with a lesion of endodontic origin at the apex of the mesial root of the mandibular left first molar (Figure 15). A complete root canal treatment of the 2 mesial canals appeared to be present in the radiograph. The etiology of the lesion was not evident. The surgical approach was selected, and the root end was beveled. Using the microscope at high power, a third canal responsible for the lesion was detected between the two treated canals (Figure 16). All 3 canals and the isthmus joining them were prepared apically and obturated (Figure 17).

Conclusion

The introduction of the surgical operating microscope in dentistry, particularly in endodontics, has been a significant addition to the profession's armamentarium. The increased magnification and illumination have enhanced the treatment possibilities in surgical and nonsurgical procedures. Treatment modalities that were not possible in the past have become reliable and predictable. The SOM has enabled the clinician to work in a more comfortable ergonomic position, for longer durations, and with increased precision. Improved visibility has enhanced the performance of various endodontic procedures, and numerous endodontists have already incorporated the use of the SOM in their practice. Based on the clinical experience of the author and the results of preliminary studies, the use of magnification and the SOM in particular indicate promise as essential adjuncts in the dental practice of the 21st century.

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Self-Test Exercise No. 171

Please note that the self-test exercise for this article does NOT provide Continuing Education (CE) credits. You may wish to use it to test your own knowledge.

The 10 multiple-choice questions for this self-test exercise are based on the article "The use of magnification in endodontic therapy: The operating microscope" by Bertrand G. Khayat, DDS, MSD. This article is on Pages 137-144. Answers for this exercise will be published in the May 1998 issue of **PPAD.**

Learning Objectives:

This article reviews and describes the function and clinical application of the operating microscope, emphasizing its utilization in endodontic treatment. Upon reading and completion of this exercise, the reader will have an up-to-date knowledge of:

- The advantages of the operating microscope.
- The clinical application of these magnification devices.

1. The disadvantages of the loupes do NOT include:

a. Limited magnification.
b. Distortion of the magnified object.
c. Convergent optics, creating eye strain and fatigue.
d. None of the above.

2. The operating microscope was first used by:

a. Ophthalmologists.
b. Endodontists.
c. Otologists.
d. Dermatologists.

3. Binoculars of the microscope are available with which of the following tube types:

a. Straight.
b. Inclined.
c. Inclinable.
d. All of the above.

4. With the operating microscope, use of the mirror:

a. Remains essential.
b. Is optional.
c. Is unnecessary.
d. None of the above.

5. The characteristics of Galilean Optics include:

a. Focus at infinity.
b. Parallel beams of light to each eye.
c. Ability to perform long procedures without eye fatigue.
d. All of the above.

6. The accessories include:

a. A beam splitter.
b. A beam unifier.
c. A color corrector.
d. None of the above.

7. Histologically, it has been demonstrated that mesiobuccal roots contained 2 root systems:

a. 80% of the time.
b. 90% of the time.
c. Almost 100% of the time.
d. None of the above.

8. Kulild et al found that _____ of the canals could be found only with the microscope.

a. 1.0%.
b. Almost 10%.
c. 1.5%.
d. Almost 15%.

9. The "dentin map" for locating secondary mesiobuccal canals is:

a. A chart applicable to the anatomy of molars in all patients.
b. A chart designed individually for each patient.
c. A fine line, originating from the tooth formation, that connects all orifices.
d. None of the above.

10. Using the operating microscope has rendered which of the following procedures more reliable:

a. Removal of a broken instrument.
b. Repair of a perforation.
c. Passing a ledge.
d. All of the above.