Magnification in endodontics: the use of the operating microscope

Arnaldo Castellucci MD, DDS, makes use of the operating microscope for micro-endodontics

In the past decade, the dental industry has experienced an expansion of technology, instruments and materials, which has led to a true revolution in both nonsurgical and surgical endodontics.

The introduction and widespread use of the operating microscope (Figure 1) together with the power of ultrasonics and instruments for micro-endodontics are areas that have changed the face of endodontics.

Until recently, endodontics was traditionally performed by hand with radiographic confirmation. To perform a root canal treatment often meant working inside a 'black hole' and many results were achieved by chance. Today, every challenge existing in the straight portion of the root canal system, even if located in the most apical part, can be easily seen and often solved under the microscope, with magnification and coaxial illumination.

With the use of ultrasonics, the removal of posts, calcifications and broken instruments is faster, safer and easier. To locate missed canals or to negotiate calcified canals is more predictable using ultrasonic tips under the microscope.

As far as new materials are concerned, recently Mineral Trioxide Aggregate (MTA) has become available. This is a revolutionary material, extremely biocompatible, hydrophilic and capable of stimulating the healing processes as well as osteogenesis. Many studies (Holland R et al, 1999; Koh ET et al, 1998; Koh ET et al 1997; Torabinejad M et al, 1994; Torabinejad M et al, 1995; Torabinejad M et al, 1997; Torabinejad M et al, 1993) have demonstrated the growth of cementum, periodontal ligament and bone adjacent to MTA when used to seal perforations, or to seal root ends in surgical endodontics. MTA can therefore be considered the material of choice both in surgical endodontics and in non-surgical endodontics (in direct pulp capping, to repair perforations, for apical barrier techniques in treatment of open apices).

Thanks to this revolutionary progress, the long-term success rate of root canal treatments is higher and endodontic therapy today is more predictable and even more fun!

The purpose of this article is to review the advantages of the operating microscope and to give clinicians an overview of numerous applications.

Legends

Table 1

TM = (FLB/FLOL) x EP x MV

TM	Total magnification
FLB	Focal length of binocular
FLOL	Focal length of objective lengths
EP	Eypiece power
MV	Magnification value

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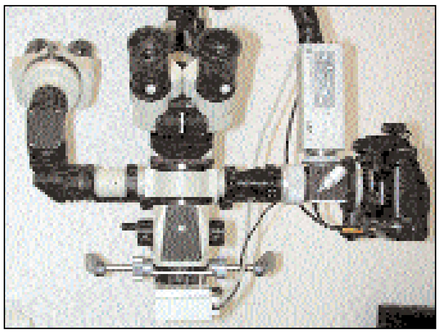
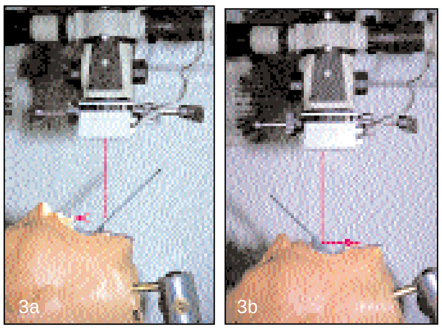


Figure 1: The operating microscope with the assistant's scope, video camera and digital camera attached

Figure 2: The operating microscope in the dental operatory



Figures 3a and b: The light of the scope should be perpendicular to the floor, perpendicular to the long axis of the examined tooth and directed to the mirror

The operating microscope

Apotheker introduced the dental operating microscope in 1981. It was poorly configured and ergonomically difficult to use. It was capable of only one magnification (8x), was positioned on a floor, poorly balanced, had only straight binoculars, and had too long a focal length (250mm). As a result, it did not gain wide acceptance (Carr GB, 1998). In 1992, Dr Gary Carr introduced an ergonomically configured operating microscope for endodontics, which allowed for

Figures 4a and b: The light from the mirror enters the root canal

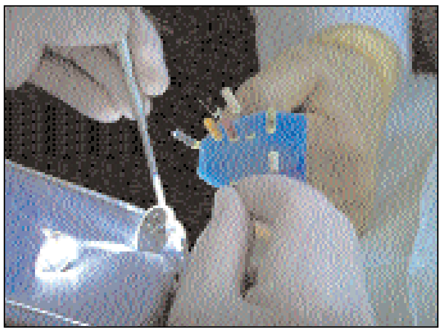


Figure 5: The hand of the operator should always be in contact with the patient's mouth and should receive each instrument directly between the fingers

Figure 6: Surgical headlight and loupes (Courtesy of Designs for Vision Inc, Ronkonkoma, NY)

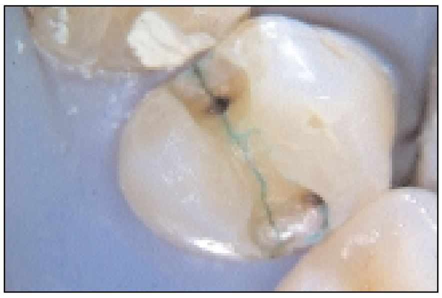


Figure 7: The patient presented with typical 'cracked tooth syndrome'. Methylene blue demonstrates a hairline fracture in the upper left first premolar

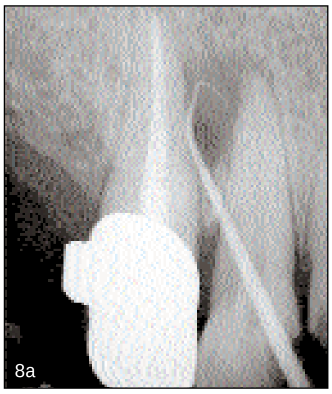


Figure 8a: The patient presented with a fistula and a lesion on the mesial aspect of the upper right cuspid

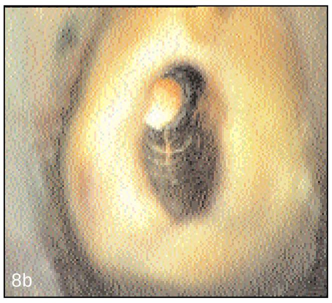


Figure 8b: After removal of the crown and the old obturating material. It is possible to make diagnosis of vertical root fracture from the inside of the root canal. The fracture is evident as a pink line on the canal wall

easy use in nearly all endodontic procedures. This pattern of microscope gained rapid acceptance within the endodontic community and is now the instrument of choice not only for endodontics but for periodontics and restorative dentistry as well (Carr GB, 1992). In the author's opinion, we are not far from the day when the operating microscope will be as common in any dental office as the X-ray machine is today.

Positioning the microscope

The introduction of the microscope in the dental office is a big revolution that involves many ergonomic changes. To reduce as much as possible any stress for the operator, the clinician should maintain the traditional working position previously used without the microscope. Working positions usually range from the 9 o'clock to the 12 o'clock position (Sheets CG, Paquette JM, 1998). It is also important for the clinician to maintain good posture with proper scope orientation (Michaelides PL, 1996) (Figure 2).

In chronological order, the microscope should be prepared and positioned as follows:

- Positioning of the operator
- Positioning of the patient
- Positioning of the microscope
- Adjusting the interpupillary distance
- Fine positioning of the patient
- Parfocaling
- Fine focus
- Adjusting the assistant scope.

To position the operator, the microscope and the patient correctly, the simplest rule to follow in nonsurgical endodontics is that the back of the operator should be straight, the light of the scope should be perpendicular to the floor and also perpendicular to the root canal where he/she is working (Figures 3a and 3b). Every single procedure in nonsurgical endodontics is made by indirect vision, therefore the light of the scope is directed to the mirror and, from there, into the root canal (Figures 4a and b). In conclusion, the position of the patient depends on the position of the scope, and not vice versa.

In surgical endodontics, where the entire procedure is carried in direct vision, everything is easier. Nevertheless, in order to be able to check the retroprep through a micro-mirror, the light of the microscope should be perpendicular to the axis of the root canal.

Ergonomics

After installing an operating microscope, it is necessary to organize the operatory ergonomically. The clinician should never move his/her eyes from the binocular and should never move his/her hands from the operating field to reach any instrument. This limits vertical dimension of movement. The operator should always stay in contact with the patient's mouth and instruments should be positioned exactly into his/her fingers (Figure 5). In nonsurgical endodontics this is achieved by the assistant who sits in front of the dentist, while in surgical endodontics it is done by a second assistant, who stands to the right of the operator and follows the surgical procedure through a monitor. During surgery, the first assistant has to keep the suction under control, so that bleeding does not interfere with visibility.

As already stated, in nonsurgical endodontics every single procedure is performed through the mirror, therefore the left hand of the operator holds the mirror all the time and orientates the light to the tooth. Sometimes the mirror is positioned close to the crown of the tooth, but many times it is positioned far from the tooth, sometimes even out of the dental arch, to allow room for the handpiece without interfering with the visibility of the operator.

Magnification

Magnification of the operating field can be achieved with the use of magnifying loupes, which can be classified by the optical method in which they produce magnification. Compound loupes use two lenses to produce magnification, while prism loupes use refractive prisms. Both of these methods produce good magnification, have excellent depth of field and can be custom made, according to the specific interpupillary distance and to personal working distance. The disadvantage of loupes is that the practical maximum magnification is only 4.5x. They are available with higher magnification but some are heavy, with limited field of view and limited depth of field. Furthermore, in my experience they require a constrained physical posture and if not used as recommended may result in head, neck and back strain.

Most operating microscopes usually possess magnification steps or increments that can be adjusted manually or with motorized foot controls. The total magnification provided by the microscope can be computed using the formula shown in Table 1, which depends on the focal length of the binocular, focal length of the objective lens, eyepiece power and magnification value (Khayat BG ,1998). The clinician should remember that most procedures are made at minimum/medium magnification, while maximum magnification is used just to check what the clinician is doing. By increasing the magnification, the illumination of the operative field diminishes, together with the depth of field and with it the width of the operative field.

Illumination

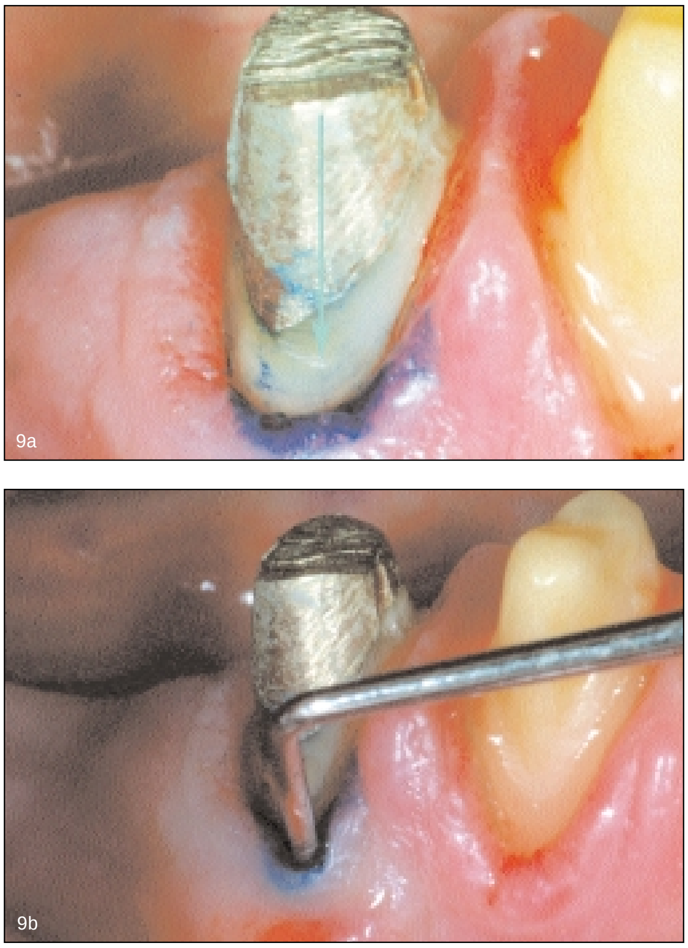
Increased illumination of the operating field can be achieved using surgical headlights mounted on loupes, using a fiberoptic cable to transmit the light (Figure 6).

Even though any head movement moves the light so that it stays in the field of view, and even if the light levels are increased up to four times that of conventional dental lights, the illumination of some loupes may not be powerful enough to allow good visibility deep inside a root canal.

The light source is one of the most important features of the microscope, as it is responsible for the illumination of the deepest portions of the root canal. This is due to the fact that the light source provides an absolutely coaxial illumination; which should enter the root canal without any angle, perfectly coaxial and with the operator's view eliminating the presence of any shadow. The light source can be powered by a halogen light bulb or by a xenon light. Some halogen lights provide an artificial yellow light, which is not ideal for documentation, so any product must be carefully selcted. I like to make use of the xenon light, which provides a white light at 5,000°K. Both light sources are connected to the microscope through a fiber-optic cable and their intensity can be controlled by a rheostat.

The operating microscope in nonsurgical endodontics

The operating microscope can be used in any single nonsurgical procedure: preparing and finishing the access cavity; shaping the root canal precisely; and filling the system completely in three dimensions. However, the enormous advantage of the microscope is better appreciated during retreatment. It is easier to diagnose a vertical root fracture, to find a missed root canal, to remove a broken instrument, to repair a perforation, or to seal a resorbed or immature apex.



Figures 9a and 9b: A vertical root fracture is evident after the use of methylene blue. A periodontal probe confirms the presence of a defect

Diagnosis

The operating microscope can be very helpful in making a diagnosis of cracked tooth syndrome. In these cases, after the old restoration has been removed, using a dye (methylene blue) a hairline fracture can be easily seen (Figure 7).

When the clinician suspects a vertical root fracture, the diagnosis can be made by observing the internal wall of the root canal (Figures 8a and 8b), eliminating the need for a surgical exploratory flap or examining the external root surface (Figures 9a and 9b).

Locating canal orifices

A perfect access cavity with visualization of all the canal orifices are prerequisites for successful endodontic therapy. The microscope can be very useful in locating hidden canal orifices, canals completely blocked by calcification in the pulp chamber and canals completely calcified in the coronal and middle two thirds.

Another advantage of the microscope is the enhanced visualization of the mesiopalatal canal (MB2) of upper first and second molars (Figures 10a, b, c and d). Recent studies confirm that this

Figure 10a: A groove is evident starting from MB1 in palatal direction, in this upper second molar

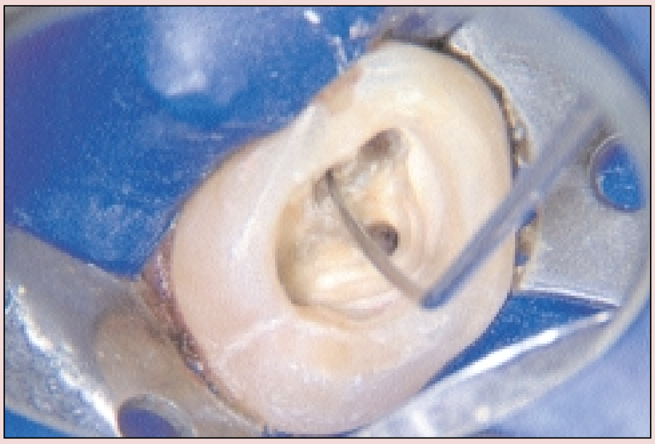


Figure 10b: The endodontic probe is demonstrates the orifice of MB2

Figure 10c: Micro-opener (Dentsply, Maillefer) is enlarging the orifice

Figure 10d: The photograph shows the orifice of MB2 after the canal has been shaped and cleaned

Figure 11a: A broken instrument is present in the apical one third of this upper first molar

Figure 11b: Using an ultrasonic tip (ProUltra, Dentsply, Maillefer), the instrument has been dislodged and now is at the orifice of the canal

Figure 11c: The radiograph is showing that the fragment has been removed

Figure 11d: Postoperative film. The patient may require a retrograde filling of the mesiobuccal root, where MB1 and MB2 were not negotiable because of complete blockage

Figure 12a: The screw post has caused a strip perforation of the mesial root of this lower left first molar. Furcal involvement is evident

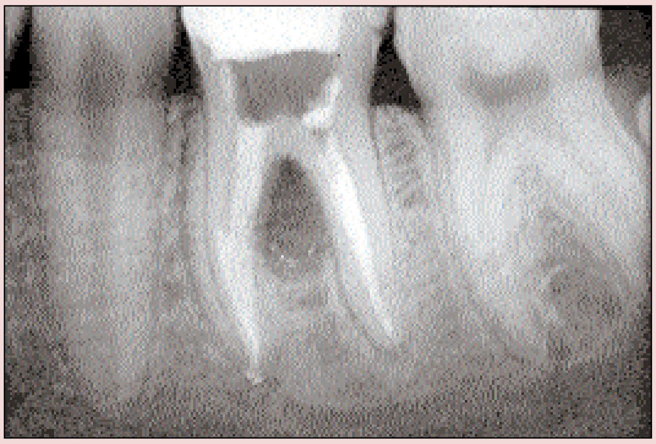


Figure 12b:. After the removal of the screw post, the distal and mesiolingual canals have been retreated and obturated with warm gutta-percha. The mesiobuccal canal has been obturated with warm gutta-percha up to the level of the perforation

Figure 12c: The mesiobuccal canal has now been filled with MTA (ProRoot MTA, Dentsply Tulsa Dental) from the perforation up to the orifice

Figure 12d: Two-year recall

Figure 13a: Preoperative radiograph of the upper left central incisor. The patient is 55 years old and the open apex is not respopnding to previous therapy with calcium hydroxide.

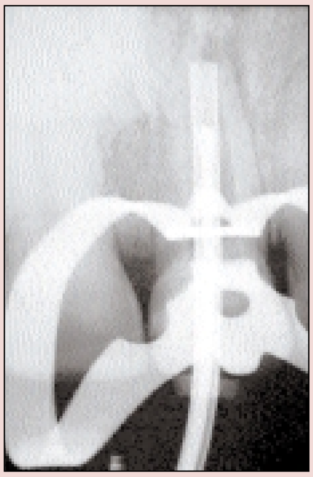


Figure 13b: Intraoperative film with the Dovgan carrier in place

Figure 13c: Three millimeters of MTA have been positioned at the foramen to make the apical barrier

Figure 13d: After the MTA is set, the thermoplastic gutta-percha has been used to obturate the root canal

Figure 14a: ProRoot MTA (Dentsply Tulsa Dental, Tulsa, Oklahoma)

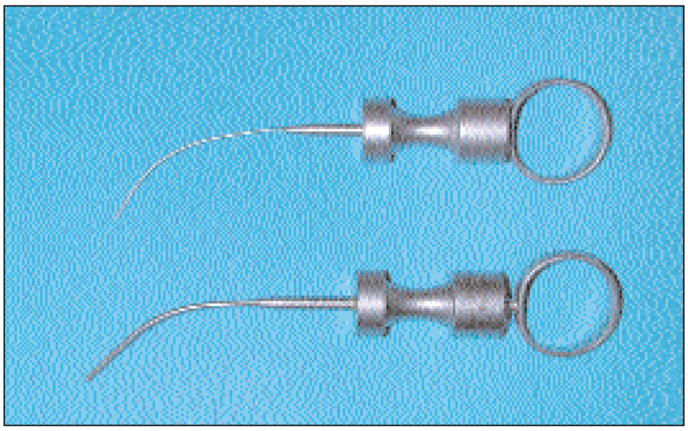


Figure 14b: Dovgan carriers (Quality Aspirators, Duncanville, Texas)

Figure 15a: Microscopic examination of the beveled root surface

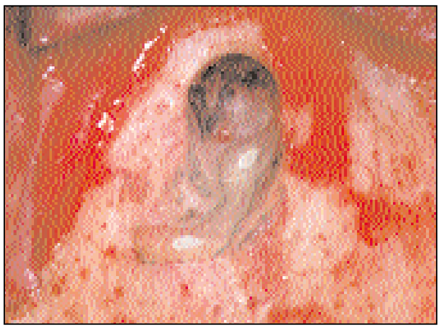


Figure 15b: Postoperative view after the two canals have been obturated with retrofilling material

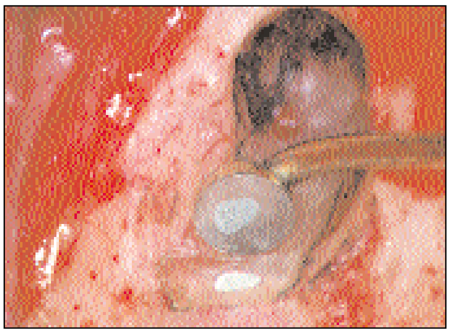


Figure 15c: The buccal canal at higher magnification

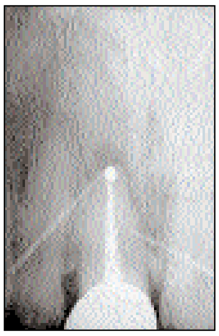


Figure 16a: The central incisor has two lesions and two fistulas; one from the apical foramen and one from a lateral canal

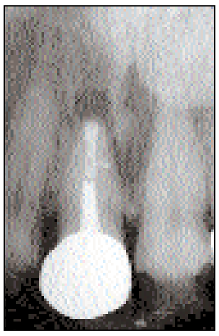


Figure 16b: During the surgical procedure, both canals have been retrofilled

Figure 16c: One-year recall

root canal does exist in nearly 100% of cases (Kulid JC, Peters DD, 1990; Stropko JJ, 1999). If we compare these results with previous studies published only 5 or 10 years ago, we can conclude that the increased percentage is not due to differences in root canal anatomy but to the better skills of the clinician who uses the operating microscope.

Retreatment

The biggest revolution due to the introduction of the microscope in nonsurgical endodontics is in the area of retreatment. Every single procedure that was previously made by chance or performed using tactile sensation can today be made with complete vision and control; if you can see it, you can do it! Any challenge existing in the straight portion of the root canal system, even if located in the most apical part, can be easily seen and often solved under the microscope with magnification and coaxial illumination.

The removal of a broken instrument (Figures 11a, b, c and d), the repair of a perforation (Figures 12a, b, c and d) and the treatment of an open apex (Figures 13a, b, c and d) using the new material MTA (Figures 14a and 14b) are procedures that can be done in predictable time with predictable results.

The operating microscope in surgical endodontics

Surgical endodontics is an area that has benefited the most from a microsurgical approach. The introduction in 1990 by Excellence in Endodontics (EIE) of a dedicated microsurgical armamentarium has revolutionized surgical technique and vastly improved the skill level of an entire specialty. The incision is made with a microsurgical scalpel blade and, therefore, is more precise, repositioning of the flap is also more precise and later no scar is to be expected. The introduction of optical-grade micromirrors has facilitated the detailed examination of the bevelled root-end in apicectomy procedures (Figures 15a, b and c). The orifices of lateral canals can be identified, prepared and sealed, in order to obtain a three-dimensional obturation of the root canal system even with a surgical approach (Figures 16a, b and c). Ultrasonic root-end preparation has revolutionized apical surgical procedures, reducing the need for exaggerated bevels and, thus, reducing osseous crypt size.

Microscopic techniques have also led to the development of soft tissue management techniques, including microsurgical suturing and the early removal of sutures, which has resulted in more rapid wound healing and minimal scar formation (Figures 17a, b, c, d and e).

Recent studies show that surgical endodontic procedures per-

Figures 17a and b: Suture in place after surgery on the lateral incisor

Figure 17b: Magnified

Figures 17c and d: Removal of the suture after 48 hours

Figure 17d: Magnified

Figure 17e: Complete healing with no scar at the one-year recall

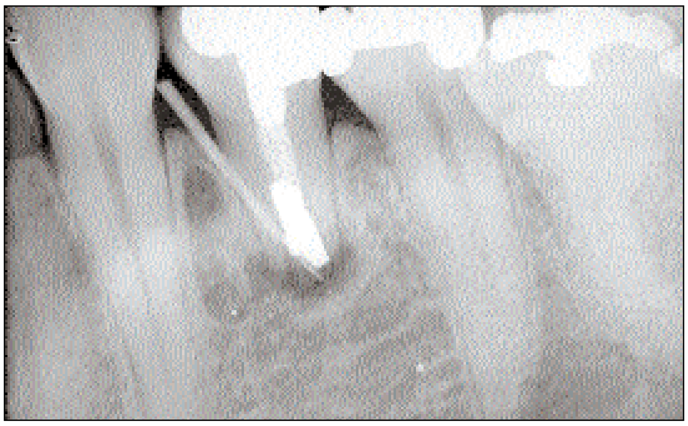


Figure 18a: Preoperative radiograph of the lower left first premolar. The previous surgical procedure is failing. A fistolous track is present

Figure 18b: Postoperative radiograph after the surgical retreatment. The old amalgam has been removed and the retroprep has now been filled with MTA

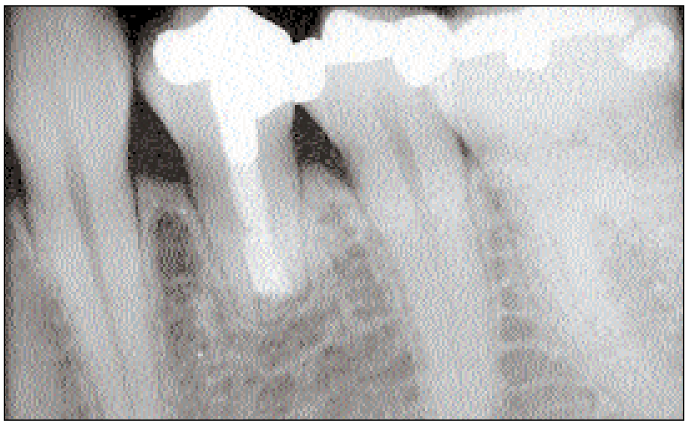


Figure 18c: The one-year recall shows complete healing, with lamina dura surrounding the end of the root

formed under the operating microscope are followed by a success rate of 96.8%, with an averagearly removal of the sutures, which has resulted in more rapid wound healing time of 7.2 months (Figures 18a, b and c).

Conclusion

The introduction and use of the operating microscope in endodontics represents a qualitative leap for the profession. Magnification and coaxial illumination have enormously increased the possibility of saving teeth both nonsurgically and surgically. Difficult cases can today be treated with a higher degree of confidence and clinical success. It is not far from the day when the operating microscope will be a common fixture in the dental office.

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Arnaldo Castellucci to lecture and give a hands-on session in London this month!

Arnaldo will be lecturing at the 'Power up your practice' seminar, held by Independent Seminars, on 5-6 September 2003 at the Royal College of Physicians, London.
His lecture 'The state of the art in modern endodontics' will look at new developments in endodontics and how they can be implemented into a dental practice to create higher success rates for root canal treatment with more predictability and more fun!
He will also hold a hands-on workshop to a limited number of participants who will have the opportunity to prepare a plastic block and extracted tooth with new GT Rotalry Files.

The following highly regarded speakers will also be lecturing and holding workshops:
Dr Nicolas Jedynakiewicz
Dr Laetitia Brocklebank
Dr Nigel Saynor
Dr John Meechan
Peter Finke
Dr Fred Bergmann
Chris Barrow

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The GDC Lifelong Learning Scheme

In October 2000, the GDC launched the preparatory scheme for its lifelong learning initiative. The scheme requires that dentists will have to accumulate 250 hours of CPD credits over five years. 75 of these hours must be verifiable. The GDC also suggests that these hours be spread evenly over the five years. In other words, therefore, dentists can be expected to perform approximately 15 hours of CPD per year. The *Endodontic Practice* CPD Programme will enable practitioners to guarantee hitting this annual level of CPD in one go.

Two articles will be featured in *Endodontic Practice* each issue which will each be equivalent to one hour of verifiable CPD. To receive credit, complete the multiple choice test after each article and return for processing. Answers can be posted to *Endodontic Practice* Verifiable CPD, FMC Ltd, Freepost NAT2688, Shenley WD7 9BR (no stamp required within the UK), faxed on 01923 851778 or emailed to cpd@fmc.co.uk.

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