Magnification in endodontics: the use of the operating microscope

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

Amongst all the innovations, the introduction and diffusion of the operating microscope (Figure 1) together with the powerful ultrasonic units and the instruments for micro-endodontics are the most important.

Until recently, the endodontic therapy was traditionally performed using the tactile sensation of the clinician and the root canal system could only be observed radiographically. To perform an endodontic therapy often meant to work 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 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 the ultrasonic tips under the microscope.

As far as the new materials are concerned, recently the Mineral Trioxide Aggregate (MTA) became available. This is a revolutionary material, which is extremely biocompatible, is hydrophilic and is capable of stimulating the healing processes and 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, as well as a retrofilling material in surgical endodontics. For all the above-mentioned characteristics, MTA can be considered the material of choice both in surgical endodontics (as a retrofilling material) and in non-surgical endodontics (in direct pulp capping, to repair perforations, for the apical barrier technique 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!

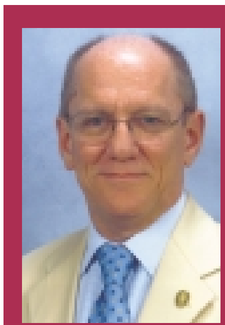
The purpose of this article is to review the advantages of the operating microscope and to give clinicians an overview of the numerous applications.

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



Dr Castellucci graduated in Medicine at the University of Florence in 1973 and specialised in dentistry at the same university in 1977. From 1978 to 1980 he attended continuing education courses on endodontics at Boston University School of Graduate Dentistry. As well as running a practice limited to endodontics in Florence, Dr Castellucci is Past President of the Italian Endodontic Society, Past President of the International Federation of Endodontic Associations, an active member of the European Society of Endodontology and the American Association of Endodontists, and a Visiting Professor of Endodontics at the University of Florence Dental School. He is editor of The Italian Journal of Endodontics and of The Endodontic Informer, Founder and President of the Warm Gutta Percha Study Club and the Micro-Endodontic Training Center. An international lecturer, he is author of the text Endodonzia, which will soon be published in English.

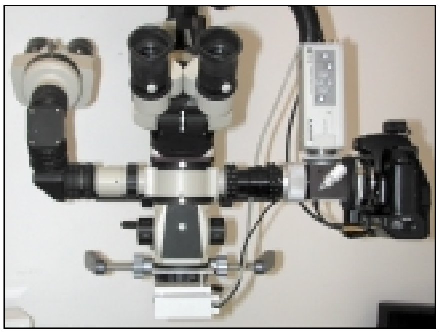
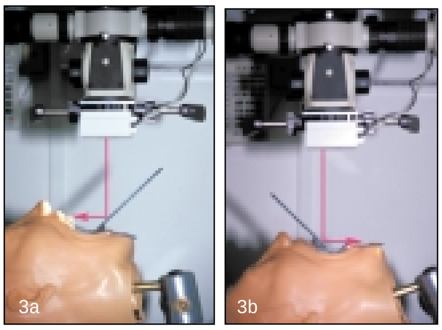


Figure 1: The operating microscope with the assistant's scope, video camera and digital camera attached

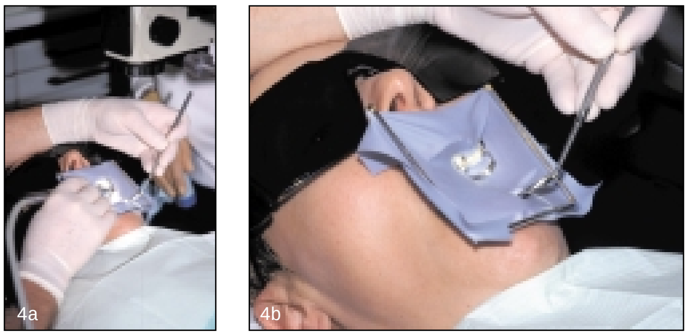
Figure 2: The operating microscope in the dental operatory



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. The first microscope as poorly configured and ergonomically difficult to use. It was capable of only one magnification (8x), was positioned on a floor stand and poorly balanced, had only straight binoculars, and



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

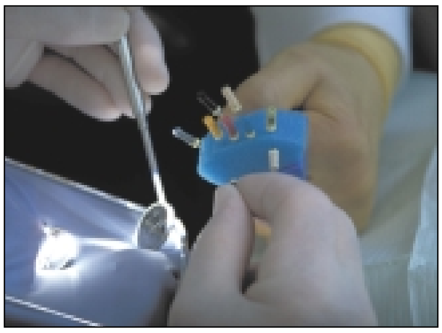


Figure 5: The hand of the operator should always be in contact with the patient's mouth and should receive each instrument directly between the fingers

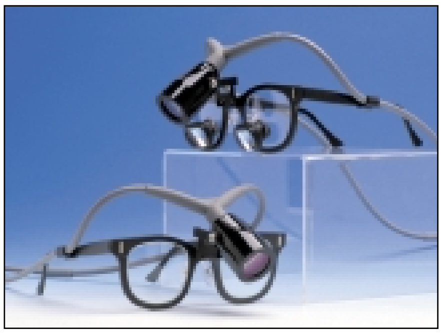


Figure 6: Surgical headlight and loupes (Courtesy of Designs for Vision Inc, Ronkonkoma, NY)

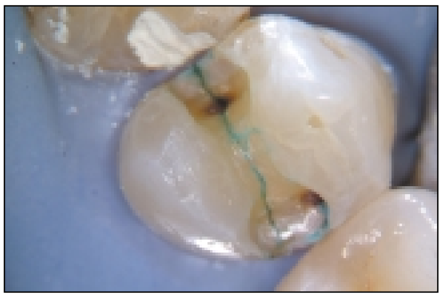


Figure 7: The patient presented the typical 'cracked tooth syndrome'. The methylene blue is showing the hairline fracture in the upper left first premolar

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

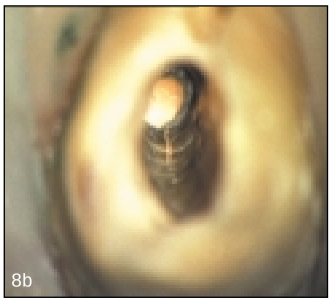


Figure 8b: After the removal of the crown, the old obturating material has been removed. Now it is possible to make diagnosis of vertical root fracture from the inside of the root canal. The fracture is evident as a pink line on the canal wall.

had too long a focal length (250mm). It did not gain wide acceptance (Carr GB, 1998). In 1992, Dr Gary Carr introduced an ergonomically configured operating microscope for endodontics with several advantages, which allowed for easy use of the scope for nearly all endodontic procedures. This 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 present in any dental office as is the X-ray machine today.

Positioning the microscope

The introduction of the microscope in the dental office is usually a big revolution and involves many ergonomic changes. To reduce as much as possible the consequent stress for the operator, the clinician should maintain the traditional working positions previously used without the microscope. The working positions usually range from the 9 o'clock to the 12 o'clock position (shhets CG, Paquette JM, 1998). It is also necessary that the clinician maintains good posture with proper scope orientation (Michaelides PL, 1996) (Figure 2).
In chronologic 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 in indirect vision, therefore the light of the scope is directed to the mirror and, from here, inside 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.

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

Ergonomics

After installing the operating microscope in the dental office, it becomes 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 operative field to reach any instrument, in order not to lose the vertical dimension of their movements. The operator should always stay in contact with the patient's mouth and the instruments should be positioned exactly among his/her fingers (Figure 5). In nonsurgical endodontics this is done by the assistant who is sitting in front of the dentist, while in surgical endodontics it is done by the second assistant, the one who is standing up to the right of the operator and follows the surgical procedure through the 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 orients the light to the tooth. Sometimes the mirror is positioned close to the crown of the tooth, but many times the mirror 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 operative 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 the personal working distance. The disadvantage of loupes is that the practical maximum magnification is only 4.5x. They are also available with higher magnification, but they are heavy, with limited field of view and limited depth of field. Furthermore, they require a constrained physical posture and cannot be worn for long periods of time without producing significant head, neck and back strain.

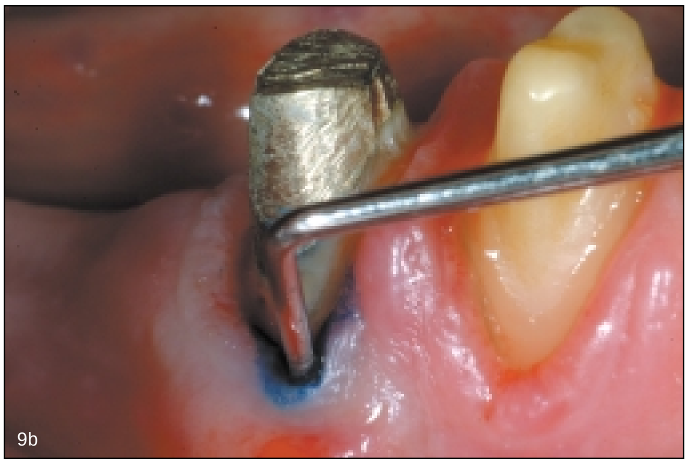
The operating microscope usually possesses magnification steps or increments that can be adjusted manually or with motorized foot controls. The total magnification provided by the microscope can be computed using the formula shown in Table 1 and it depends on the focal length of the binocular, focal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

Illumination

A better illumination of the operating field can be achieved using the surgical headlight mounted on the loupes, using a fiberoptic cable to transmit the light (Figure 6).
Even though any head movement moves the light and even if the light levels are increased up to four times that of conventional dental lights, the illumination is never powerful enough to allow a good visibility deep inside the 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; the light should enter the root canal without any angle, perfectly coaxial 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. The halogen light provides an artificial yellow light, which is not indicated for documentation. The xenon light provides a white light like daylight at 5,000° Kelvin. Both light sources are connected to the microscope through a fiberoptic cable and their intensity can be controlled by a reostat.



Figures 9 a and 9b. A vertical root fracture is evident after the use of methylene blue. The periodontal probe is confirming the presence of the difect

The operating microscope in nonsurgical endodontics

The operating microscope can be used in any single procedure of a nonsurgical endodontic treatment: preparing and finishing the access cavity; shaping the root canal precisely; and filling the system completely in three dimensions. However, the enormous advantages of using the microscope are better appreciated during retreatments. It is much 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.

Diagnosis

The operating microscope can be very helpful in making diagnosis of cracked tooth syndrome. In such a case, after the old restoration has been removed, using a dye (like methylene blue) the 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 correct access cavity and visualization of all the canal orifices are essential for successful endodontic therapy. The microscope can be very useful in locating hidden canal orifices, canals completely

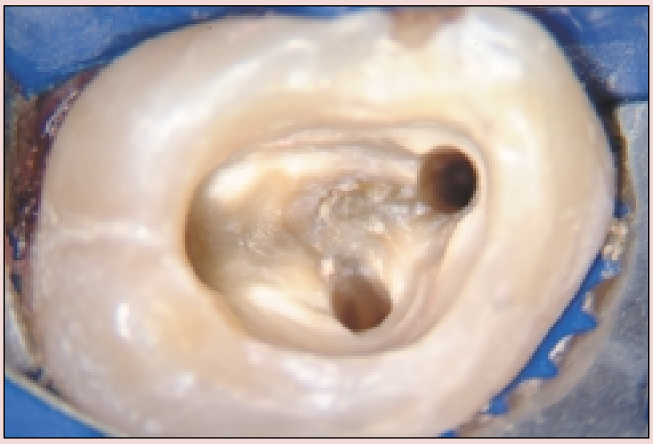


Figure 10a: A groove is evident starting from MB1 in palatal direction, in this upper second molar

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

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

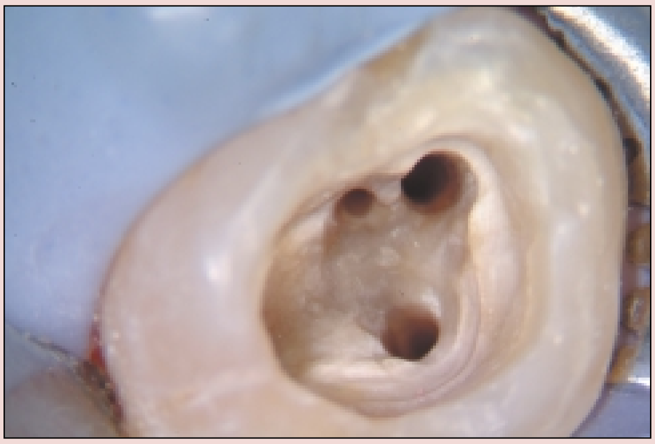


Figure 10d: The photograph is showing the orifice of MB2 after the canal has been shaped and cleaned

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 totally removed

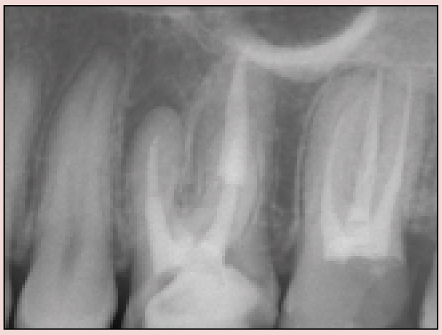


Figure 11d: Postoperative film. The patient now needs a retrograde filling of the mesiobuccal root, where MB1 and MB2 were not negotiable because completely blocked

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

Figure 12b:. After the removal of the screw posts, 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

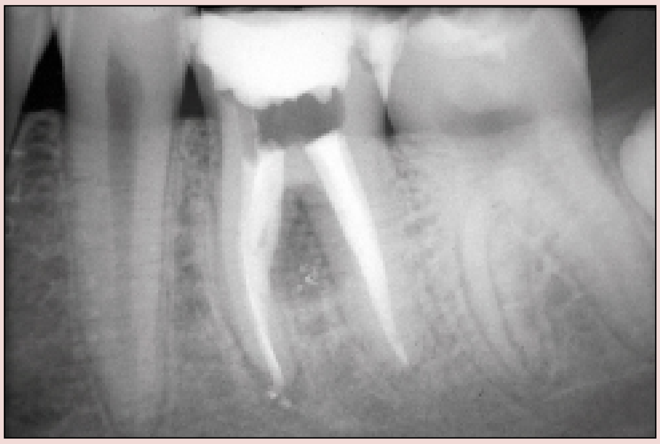


Figure 12c: The mesiobuccal canal has now been filled with MTA (ProRoot MTA, Dentsply Tulsa Dental) from the perforation up to the orifice

Figure 12d: Two-year recall

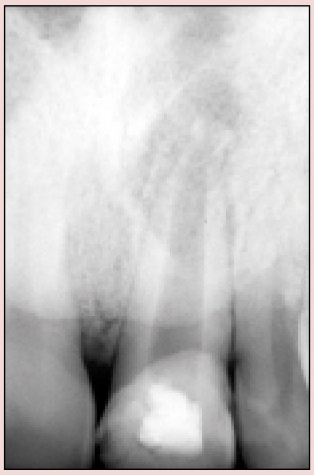


Figure 13a: Preoperative radiograph of the upper left central incisor. The patient is 55 years old and the open apex is not respopnding to previous therapy with calcium hydroxide.

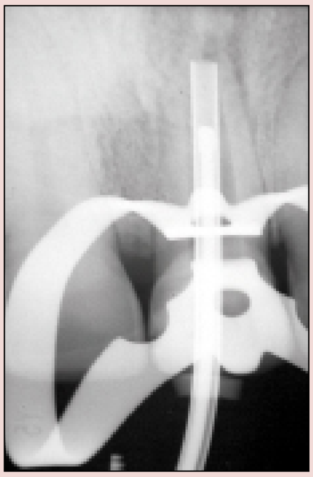


Figure 13b: Intraoperative film with the Dovgan carrier in place

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)

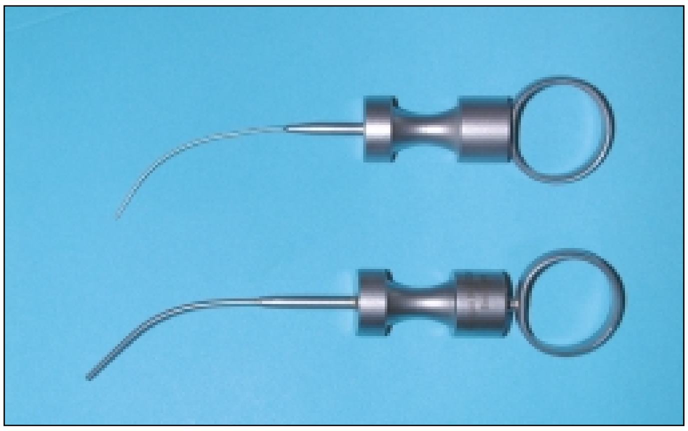


Figure 14b: Dovgan carriers (Quality Aspirators, Duncanville, Texas)

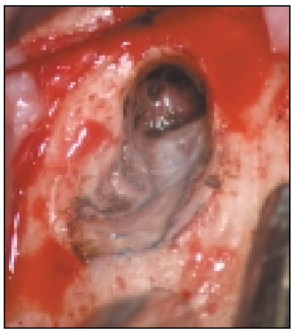


Figure 15a: Microscopic examination of the beveled root surface

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

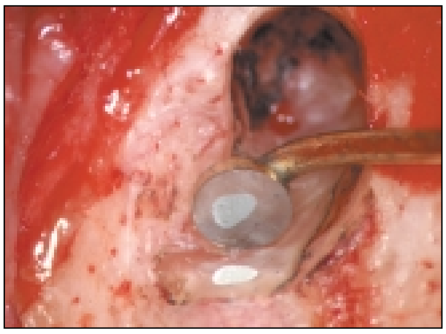


Figure 15c: The buccal canal at higher magnification

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

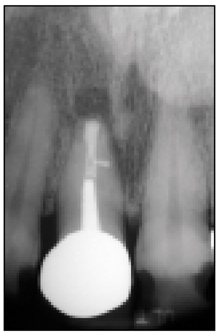


Figure 16b: During the surgical procedure, both canals have been retrofilled

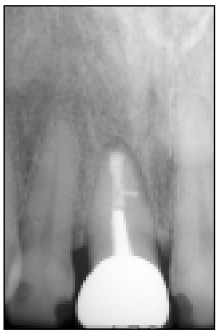


Figure 16c: One-year recall

blocked by calcifications in the pulp chamber and canals completely calcified in the coronal and middle two thirds.

Another advantage of the microscope is the easy visualization of the mesiopalatal canal (MB2) of upper first and second molars (Figures 10a, b, c and d). Recent studies confirm that this root canal does exist in a percentage very close to 100% (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 the changes of the root canal anatomy but to the better skills of the clinicians who use the operating microscope.

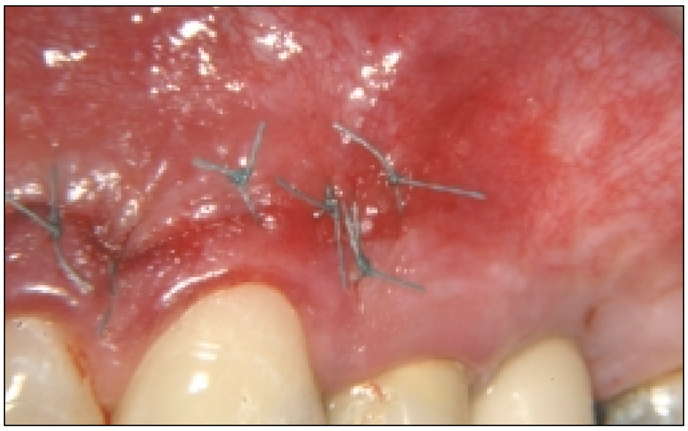
Retreatment

The biggest revolution due to the introduction of the microscope in nonsurgical endodontics is in the retreatment field. Every single procedure that was previously made by chance or performed using the 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 solved under the microscope with magnification and coaxial illumination.

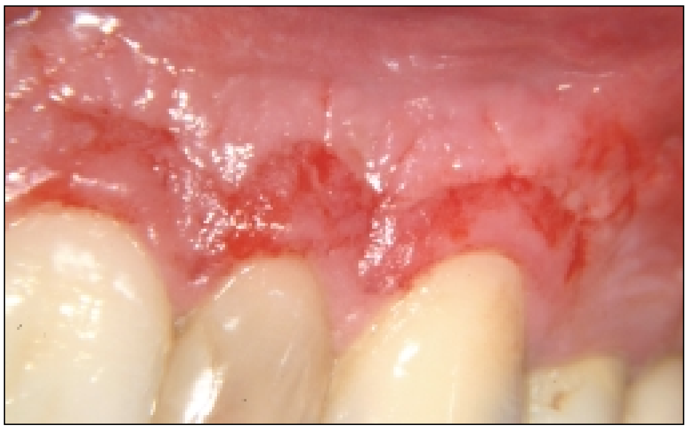
The removal of a broken instrument (Figures 11a, b, c and d), the repair of a perforation (Figures 12a, b, c and d) and the treatment of an open apex (Figures 13a, b, c and d) using the new material MTA (Figures 14a and 14b) are procedures that can be done in predictable time with predictable results.

The operating microscope in surgical endodontics

Surgical endodontics is the specialty 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 there will be no scar. The introduction of optical-grade micromirrors has facilitated the detailed examination of the bevelled root-end in apicoectomy 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 by reducing osseous crypt size.



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



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

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

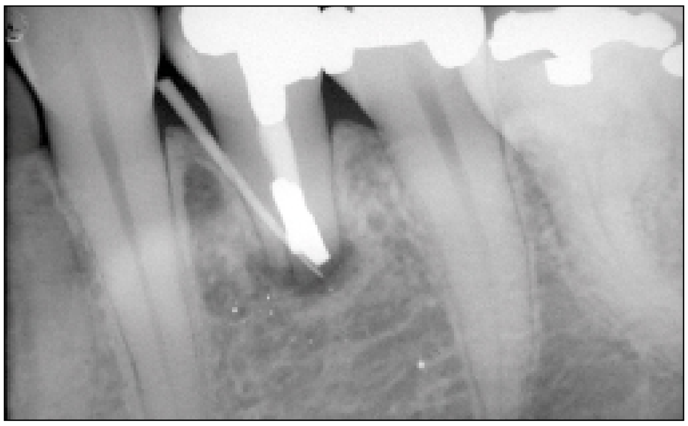


Figure 18a: Preoperative radiograph of the lower left first premolar. The previous surgical procedure is failing. A fistolous track is present

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 is showing a complete healing, with the lamina dura surrounding the end of the root

Microscopic technique has also led to the development of soft tissue management techniques, including microsurgical suturing and the early removal of the 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 performed under the operating microscope are followed by a success rate of 96.8%, with an average healing rate of 7.2 months (Figures 18a, b and c).

Conclusion

The introduction and diffusion 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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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.