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Micro-Surgical Endodontics

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INTRODUCTION

Surgery, as defined in Webster’s, “is the art, practice, or work of treating diseases, injuries, or deformities by manual or operative procedures”.⁶⁸ Therefore almost all endodontic treatment can be described as a surgical procedure. However, this chapter will confine itself to the more traditional “surgical” vs. “non-surgical” endodontic classification.

In 1960, Maynard K. Hine wrote, “The noteworthy refinement of dental techniques that has occurred in all branches of dentistry is especially striking in endodontics, so that the informed dentist can now restore the masticatory system much more effectively than ever before”. Later, on the same page, he went on to say, “No longer can one conscientiously extract all pulpless teeth, because utilization of modern techniques in endodontics will ensure the safe retention of many teeth which at one time not too long ago would and should have been extracted”.²⁸ Almost a half century later, these words are still true and more prophetic than ever. A recent epidemiological study, done in a large patient

population and over a long follow-up period, was a clear indication for assessing the outcome of endodontic treatment. It showed that of nearly 1.5 million endodontically treated teeth in over 1.1 million patients there was a 97% success rate over a period of 8 years.⁵⁹

Microscopes and endoscopes for enhanced vision

The specialty of endodontics changed drastically in less than a decade with the introduction of the Surgical Operating Microscope (SOM) that provided greatly enhanced vision for the operator. There are numerous SOM manufacturers, each with different models and accessories available to enhance comfort, efficiency, vision and documentation. More recently, arthroscopic-type systems are being adapted for micro-dental use by Storz and Jed-Med to allow even better vision in certain situations. In general, these endoscopes (ES) have several major differences when compared to the SOM:

SOM	ES
1) Three dimensional	Two dimensional
2) Magnification changed by “stops”	Magnification changed by distance
3) Viewed direct	Viewed on monitor
4) No hands necessary to hold in place	Use of one hand to hold hand piece
5) Lenses for vision	Fiber optics for vision
6) Movements viewed actual	Movements may be reversed
7) Vision is “line-of-sight”	Vision extended to “hidden” areas
8) Assistant can view field directly	Assistant views on monitor
9) Various attachments possible	Attachments limited
10) Financial outlay usually greater	Financial outlay usually less

Please note: ES, as used in this chapter, refers to the type of equipment, not a product name.

There is no real advantage, or disadvantage, when comparing the SOM to the ES, because it depends entirely upon the situation presented to the surgeon. There are certain procedures that are better suited for the SOM; and others that are better suited for the ES. For example, after curettage of a lesion that occupied the lingual space of a root, it can be very difficult using a SOM, to thoroughly inspect the entire lingual surface of the root if a vertical fracture, accessory canal, or apical plaque, was suspected to be present. The inspection of the buccal surface of the crypt, to be sure all pathological tissue has been removed, can also be difficult, requiring the use of a micro-mirror to visualize the area. However, due to the slender shape, and beveled fiber optic lens the ES has, this can be easily accomplished (Fig. 34.1). Another



Fig. 34.1. The slender “rod-like” shape, the beveled angles, and the various diameters of the endoscope lenses permit viewing difficult areas of the tooth and crypt. In some cases, the endoscope provides better vision than the SOM.

example, in favor of the SOM would be the difficulty of using the ES during the incision or while suturing. In order to experience the full advantage of operating in the “World of MicroEndodontics”, both the SOM and an ES should be available for the operator. Computers and digital cameras can be attached to both units and be programmed to capture the details of the techniques employed. And, improvements are constantly being made to both pieces of equipment to make them even better adapted to MicroEndodontics. These advanced technologies allow better precision, easier usage, and predictability of the surgical result. They have become indispensable teaching tools, allowing the students to share the surgical experiences visually as never before.

Procedures previously thought impossible to accomplish are becoming a matter of routine. The endodontic practitioner can now safely remove separa-

ted instruments, locate missed canals, repair perforations, and expect predictable results following most surgical and non-surgical endodontic procedures. To allow the full use of vision enhancement; new instruments, materials, and techniques have evolved and are constantly being refined. Modern microsurgical techniques can usually correct an unfavorable response to “non-surgical” treatment, but in no fashion should be used as an alternative to the utilization of good and conscientiously performed endodontic treatment principles (Fig. 34.2).

Gary Carr, DDS laid the groundwork for MicroEndodontics to become the new standard of excellence in endodontics. His work has made the

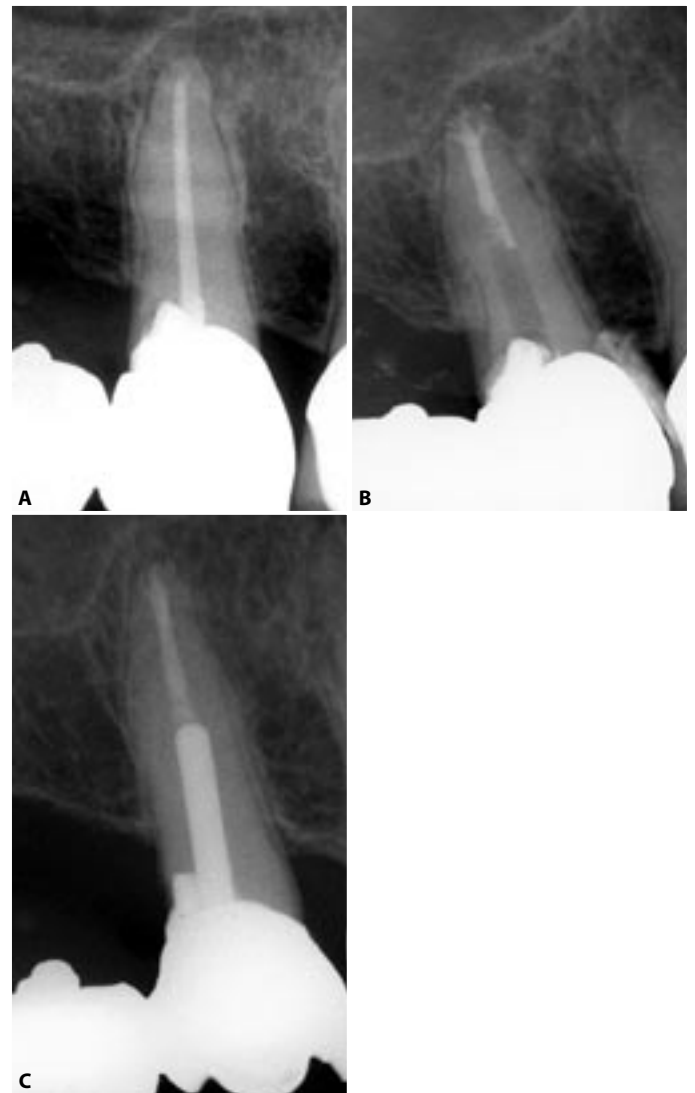


Fig. 34.2. **A.** Pre-op radiograph showing incomplete endodontics with fill well short of the apex. **B.** Immediate post-op of non-surgical retreatment showing more complete filling of the canal system and the presence of an “apical delta”. **C.** This 2-1/2 year post-op radiograph demonstrates complete healing without surgical endodontic treatment.

dental operating microscope (SOM) a necessary and valuable tool enabling endodontic procedures to be performed that were considered impossible less than a decade ago. Since 1992, some of his students and others have made vast improvements in equipment, instruments, materials, and technology. Endodontic treatment has been elevated to a new level and most of our past beliefs have changes drastically.

The current protocol for apical microsurgical procedures is a result of the combined efforts of endodontists, manufacturers, dental schools, and others that have become caught up in the excitement of this new standard of excellence, previously unparalleled in our dental specialty. The results attainable today are very predictable and can be achieved by anyone, provided the protocol is followed in detail. It is of utmost importance to totally complete each step before proceeding to the next one. Otherwise the unfinished, unsuccessful, or neglected step will make the following procedures difficult, and sometimes impossible, to achieve the desired result. If the proper protocol is followed, according to a recent 5-7 year study by Richard Rubenstein, DDS, the current apical microsurgical technique has a heal rate of approximately 91.5%.⁵⁷

Endodontic Surgery or Surgical Endodontics ?

An important distinction must be made. The procedure that will be described in this chapter it is not a Surgical Procedure made for endodontic reasons: the tooth has a granuloma or a cyst at the apex and therefore a surgical operation is needed for the removal of the inflammatory tissue. It is rather an Endodontic Treatment made through a surgical flap. In other words, the surgical operation must be made with the knowledge, the skillfulness and the hand of the Endodontist, who takes care of cleaning, shaping and three-dimensionally obturating the root canal system with a surgical approach just because (this is what happens most of the time) the root canal system was not negotiable non surgically (Fig. 30.18).

Indications for Surgical Endodontics

If the canal system is cleaned, sterile and thoroughly obturated, thereby removing the primary source of infection, the lesion of endodontic origin (LEO) has a great ability to heal completely.⁶⁰ However, due to various predisposing constraints, which may be present, the operator cannot always ac-

complish the desired complete three-dimensional obturation of the canal system. There may be hidden anatomical anomalies, calcifications, apical calculus (to be discussed later in the chapter), iatrogenic ledges or perforations, accessory canals, posts, separated instruments, etc. preventing the most judicious operator from achieving the goal of thoroughly shaping, cleaning, and obturation of the entire canal system. If a canal space is not completely instrumented, or inadequately treated, the outcome of the surgical procedure will be more likely to have a poor response to treatment.^{9,20,30}

Due to the numerous advancements in techniques, equipment, instruments, and materials, some of the previous indications for apical surgery are no longer valid. Good examples of *false indications* for apical surgery are:

1) very large lesions of a centimeter or more (Fig. 34.3)

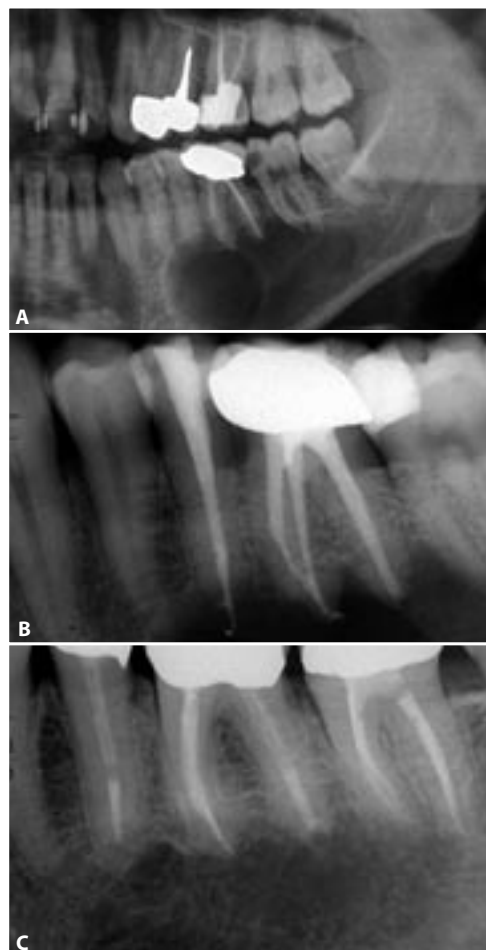


Fig. 34.3. **A.** The panoramic radiograph shows the presence of a large cyst involving several teeth, from the first premolar to the second molar. The first premolar tested vital, the second premolar had a necrotic pulp, the first molar needed a retreatment and the second molar had a pulp exposure. **B.** Postoperative radiograph after nonsurgical treatment. **C.** Five year recall. (Courtesy of Dr. Arnaldo Castellucci).

- 2) whether the LEO was a cyst or granuloma
- 3) a sinus tract is present (Figs. 8.6 – 8.11)
- 4) excess filling material extruded from the apex (Figs. 24.68 -24.71, 34.4)
- 5) an open apex (see Chapter 29).

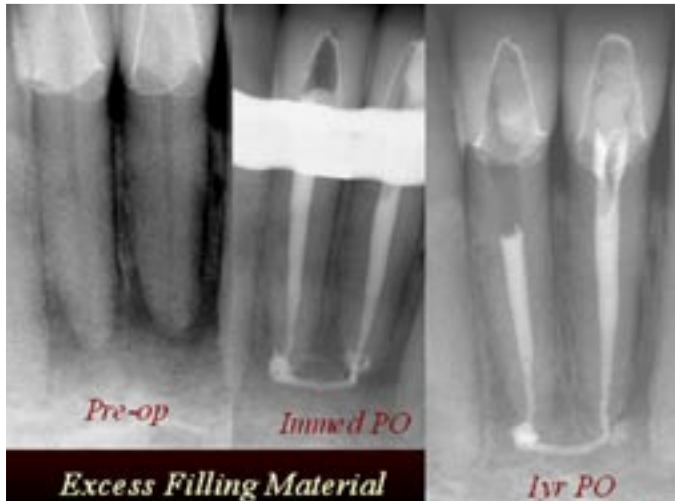


Fig. 34.4. If the canal system is adequately sealed, excess filling material at the apex is not an indication for apical surgery.

Currently, all of the aforementioned “indications for surgery” can successfully be addressed by non-surgical retreatment. If the canal system can be successfully shaped, cleaned and obturated, it will respond favorably to conventional treatment. After all non-surgical endodontic treatment has been considered or exhausted; surgical intervention may be the only alternative for removal of the source of infection and the restoration of the patient’s optimal oral health.

The only time surgical endodontics should be considered is when it is impossible to get a good apical seal in a “virgin” case, or to improve the apical seal in a “retreatment” case with a non-surgical approach. Apical surgery is also indicated when there is the probability of the presence of an extra canal infection process, or foreign object, on the periapical root surface that has to be removed.

Contraindications for Surgical Endodontics

Apical surgery is not automatically indicated as an option to retreatment. There are various circumstances present that apical surgery cannot correct.

Lateral lesions of endodontic origin (LEO)

These lesions are many times impossible to access surgically, especially if they are even slightly to the lingual, or palatal (Fig. 34.5 A, B). These cases should always be treated non-surgically first in an attempt to eliminate a lateral accessory canal (Figg. 34.6 A-C). In some other rare occasions the lesion is just mesial or distal and if that lateral canal is the only portal of exit responsible of the lesion, the surgical approach can be successful just sealing the lateral foramen (Fig. 34.7).



Fig. 34.5. **A.** The radiograph shows a lateral lesion: this is an indication for a non-surgical retreatment. **B.** Two year recall: a small lateral canal has been filled on the distal aspect of the root. (Courtesy of Dr. Arnaldo Castellucci).

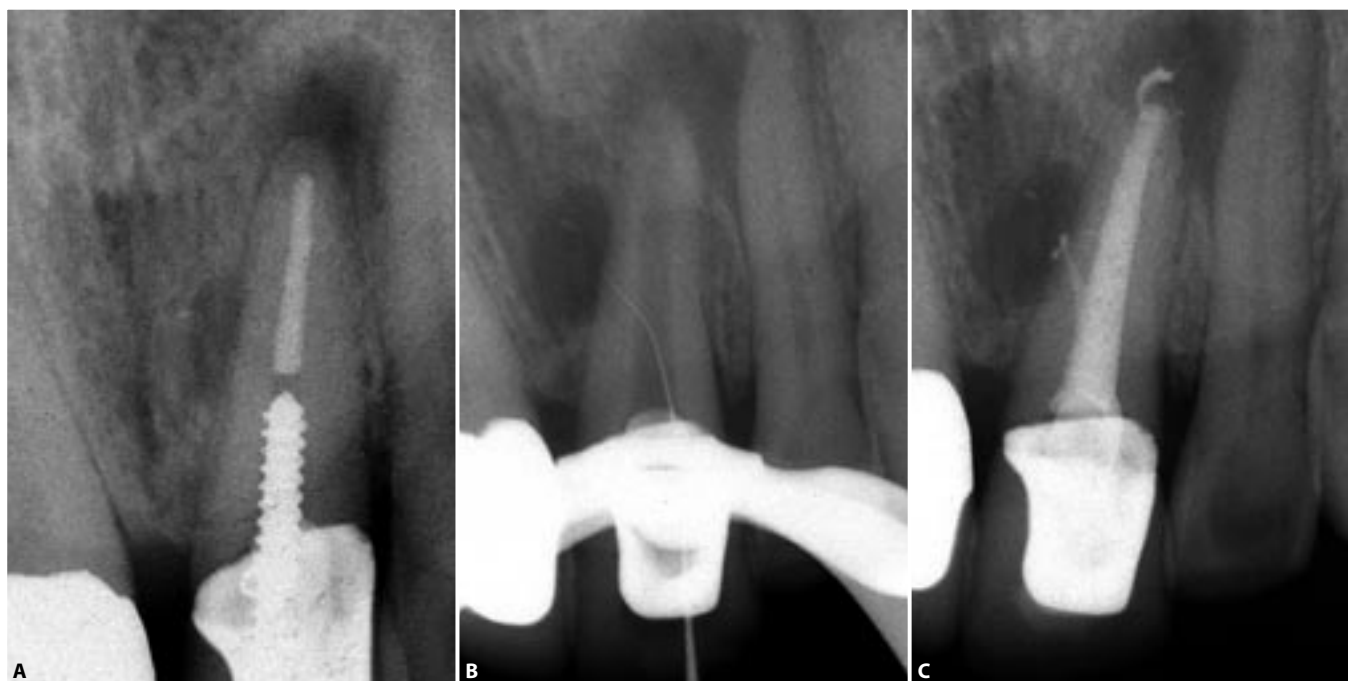


Fig. 34.6. **A.** Pre-op radiograph of patient referred for surgical endodontics. Notice the lateral LEO. **B.** After careful disassembly and using high powers of the SOM, the lateral accessory was located and instrumented. **C.** Immediate post-op radiograph shows the canal system was successfully obturated and surgery was avoided.

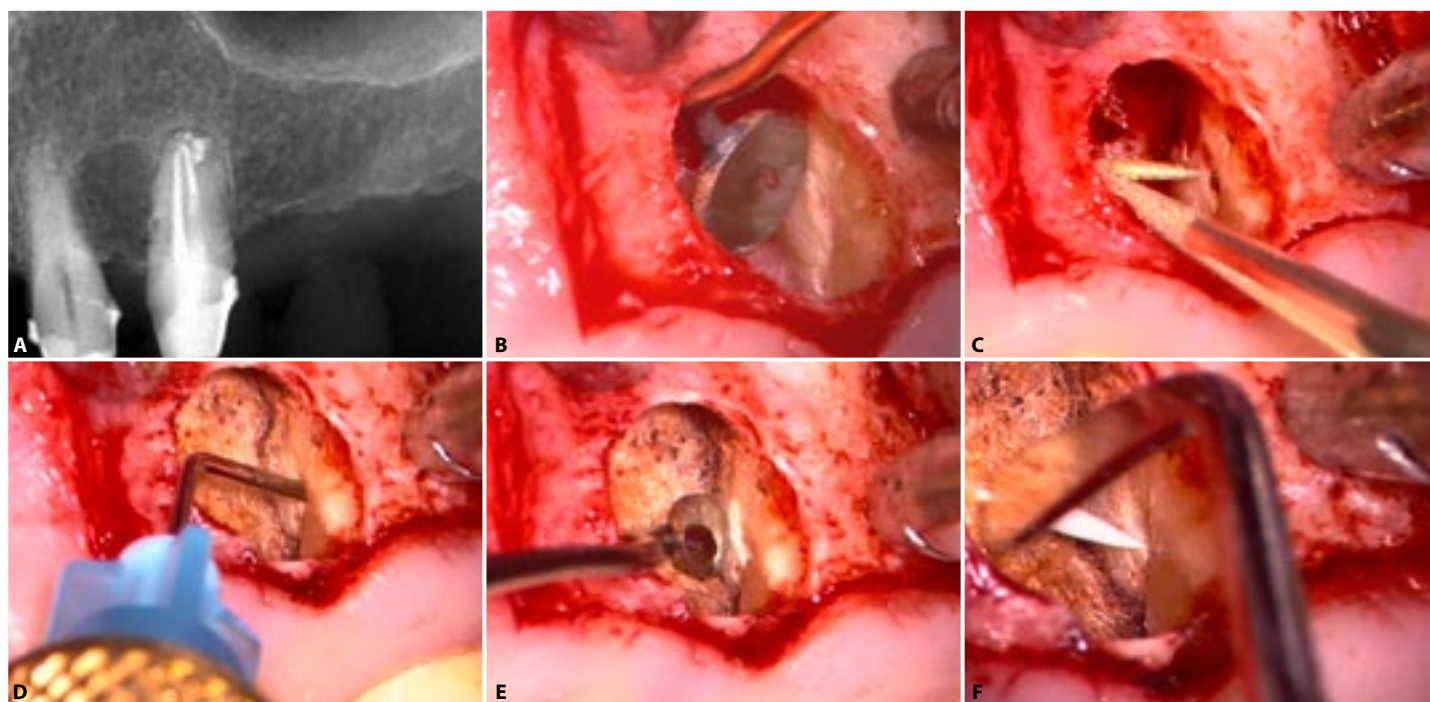


Fig. 34.7. **A.** Pre-op radiograph of patient referred for surgical endodontics. Notice the lateral LEO. **B.** The micro-mirror shows the opening of the lateral canal. **C.** The ultrasonic tip is preparing the lateral cavity for the retrofill. **D.** The cavity is now dried with the Stropko Irrigator. **E.** The cavity is now ready to be obturated. **F.** The retrofilling material is being carried in the cavity. (continued).

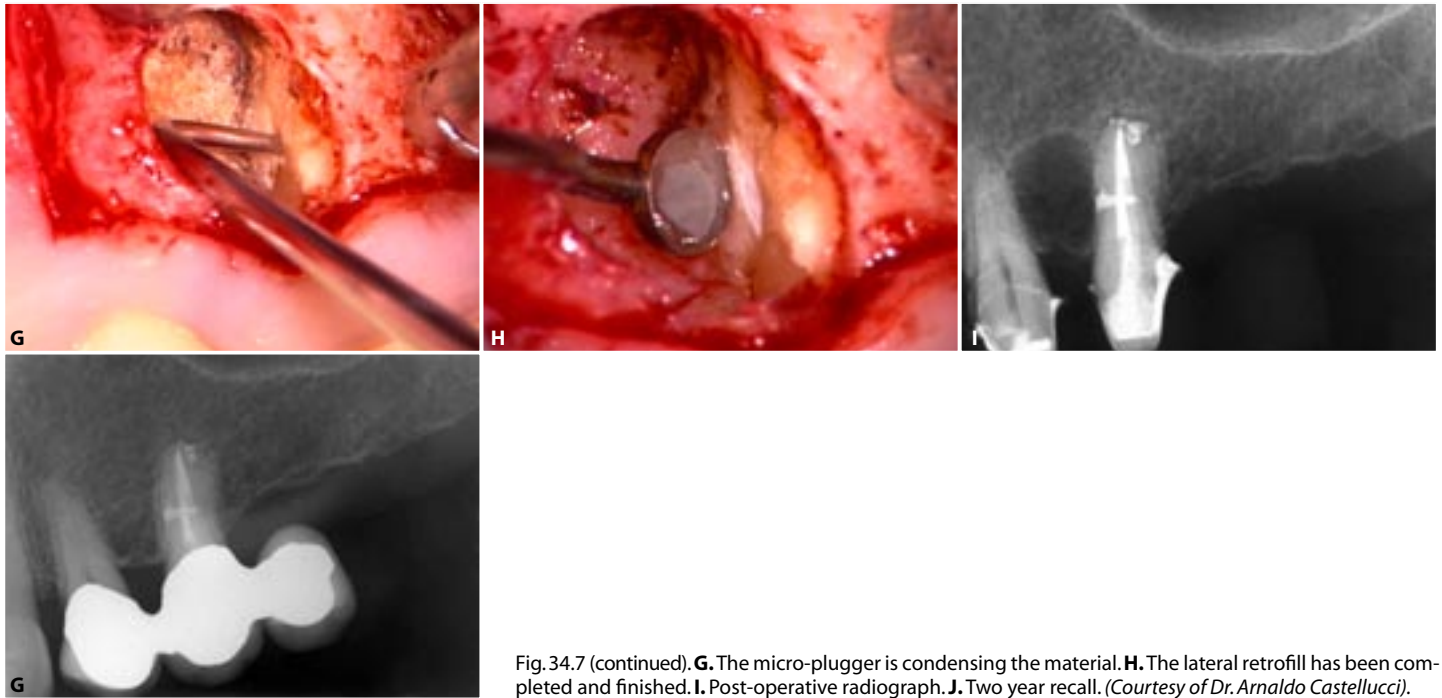


Fig. 34.7 (continued). **G.** The micro-plugger is condensing the material. **H.** The lateral retrofill has been completed and finished. **I.** Post-operative radiograph. **J.** Two year recall. (Courtesy of Dr. Arnaldo Castellucci).

Unfavorable Crown-Root Ratio

It is necessary that the root end be beveled 2-3 mm to eliminate most of the apical problems. If the Crown-Root Ratio is 1:1 or less, apical surgery will only exacerbate an already poor long-term prognosis by decreasing the ratio. Periodontal pockets, or disease, can also contribute to decreasing the available bone supporting the tooth. If there is lack of boney support, other treatment may be indicated such as retreatment, extraction, implants, bridges, etc.

Vertical Root Fractures

Although someone occasionally claims success in treatment of vertical root fractures, the prognosis is always guarded. The patient has to be advised that the tooth may be lost and the long term prognosis is not favorable. The diagnosis of a vertical root fracture is often first indicated when probing the sulcus. A typical scenario would be to probe 2-3mm pockets all around the tooth, and then suddenly measure a depth of 6, or more, millimeters. This usually denotes a dehiscence of bone and decreases the chances of a succes-

ful surgical result. After the surgical flap is reflected, and a vertical fracture is suspected, the area should be stained with Methylene blue dye for confirmation. The alternative treatment modalities then have to be re-evaluated with the patient.

Medical Considerations

Past Medical History

It is imperative for the operator to be completely familiar with the patient's past medical history (PMH). If the PMH is not current, the potential risks and/or complications cannot be anticipated. The medical considerations for any endodontic surgical procedure are no different than required by any other type of dental or oral surgery.

Often the general appearance of the patient can be an indication that further clarification of the PMH is necessary. In addition to the basic Medical History evaluation taken from the patient at the time of registration, certain basic questions have to be asked (Fig. 34.8):

PATIENT MEDICAL HISTORY		
PHYSICIAN NAME _____	PHONE _____	
In Case of Emergency Contact: Name _____	Relationship _____	Phone _____
PHARMACY _____	PHONE _____	
Please Check Yes or NO	Yes	No
Date of Last Physical Exam _____		
1. Do you have unhealed injuries, or inflamed areas, growths or sore spots in and around your mouth?	☐	☐
2. Has there been any change in your general health within the past year?	☐	☐
3. Are you under the care of a physician for a current problem? If yes, explain _____	☐	☐
4. Have you been hospitalized within the past 5 years? Please specify. _____	☐	☐
5. Have you received therapy for alcoholism or drug addiction during the past 5 years?	☐	☐
6. Have you ever had an ADVERSE REACTION To: <u>PENICILLIN</u> <u>NOVACAINE</u> <u>CODEINE</u> <u>ASPRIN</u> <u>LATEX</u> Any Others? _____	☐	☐
7. Is there any condition concerning your health the Doctor should know about? Please specify- _____	☐	☐
8. Do you wish to speak to the Doctor privately about anything?	☐	☐
9. Have you had abnormal bleeding with previous extractions, surgery or trauma?	☐	☐
10. Have you ever required a blood transfusion?	☐	☐
11. Have you ever had surgery and/or radiation for a tumor, growth or other condition?	☐	☐
12. Have you ever been tested positively for HIV infection or AIDS? If yes: date diagnosed and treating doctor's name _____	☐	☐
13. Are you required to take an antibiotic prior to dental treatment?	☐	☐
14. Women only--Are you pregnant nursing or taking birth control pills?	☐	☐
15. Do you have or have you had any of the following? Please check <u>ALL</u> that apply:		
☐ High blood pressure ☐ Heart murmur or prolapsed valve ☐ Joint prosthesis (hip, knee, etc.) ☐ Rheumatic fever or Rheumatic heart disease ☐ Congenital heart disease ☐ Cardiovascular disease: heart attack, stroke, or bypass ☐ Prosthetic heart valve ☐ Blood disorder (e.g. anemia) ☐ Venereal disease ☐ Asthma ☐ Allergy to Latex ☐ Low Blood Pressure ☐ Chest Pains or Angina ☐ Swollen ankles, Arthritis, or joint disease ☐ Cardiac Pacemaker ☐ Heart Surgery ☐ Delay in Healing ☐ Tuberculosis ☐ Emphysema ☐ X-ray Treatment or Chemotherapy ☐ On a diet ☐ History of Alcohol Abuse ☐ Eye Disease or Glaucoma ☐ Infectious Mononucleosis	☐ Sinus trouble ☐ Thyroid problems ☐ Diabetes ☐ Stomach ulcer, colitis ☐ Hepatitis, jaundice, liver disease ☐ Kidney Problems ☐ Psychiatric Treatment ☐ Fainting spells ☐ Epilepsy ☐ Cancer ☐ Temporomandibular Joint Problems (TMJ) ☐ Low Blood Sugar ☐ Dialysis ☐ Irregular Heart Beat ☐ Contagious Diseases ☐ Bronchitis, Chronic Cough ☐ Hay Fever/Sinus Problems ☐ Problems w/ Immune System ☐ Difficult Breathing or other Lung Trouble ☐ Chronic Fatigue or Night Sweats ☐ History of Drug Abuse ☐ Wear contact Lenses ☐ Bruise Easily ☐ Gallbladder Trouble	
15. Are you taking any Herbal Medicines i.e. St. Johns Wort? If yes please list. _____	☐	☐
16. Have you ever taken the "Fen-Phen" Diet Pills?	☐	☐
17. Do you have any diseases or condition not listed above? If yes please list. _____	☐	☐
18. Are you taking any medication or drugs? Please list them below: _____	☐	☐
Signature _____ (PATIENT OR PARENT IF PATIENT IS UNDER 18 YEARS OF AGE)	Date _____	

Fig. 34.8. Sample Medical Registration that can be compatible with the computer program used in the office.

1) When you get cut, do you bleed longer than you think you should?

2) Are you taking any other medicines, recreational or herbal drugs not listed in your medical questionnaire? (E.g. often a patient doesn't consider "an-aspirin-a-day" as medication, but the coagulation time may be seriously affected)

3) Is there anything not on this questionnaire that we should know about?

Sometimes the more important things in the PMH are discovered during casual discussion. It is important to consider that patients will confide information to the doctor that they didn't feel comfortable writing down on paper or relating to one of the staff members (or visa versa). The more information gathered before the procedure, the more able the doctor can ensure a predictable outcome of the surgery. If there are any questions about the PMH, the doctor should not hesitate to consult with the patient's physician.

Antibiotic Medication

Generally, the chief concerns are histories of diabetes, strokes, circulatory or heart disease, artificial joint replacements, blood dyscrasia, liver disease, pregnancy, and aging. A thorough knowledge of the patient's medications is of utmost importance to be sure there are no contraindications, or cross-reactions, to any drugs the doctor may want to use or prescribe. Knowing the time the patient takes their medications can be important. On occasion, seeing the patient earlier, or later in the day, can make the difference between a pleasant, and, an unpleasant appointment experience.

If the patient is a diabetic, the healing powers are compromised and other considerations have to be made. Is the diabetes under control? How much, and how often do you take your medications? Is prophylactic antibiotic coverage necessary? If the patient expresses any doubt, or concern, about controlling their diabetic condition, a consultation with the patient's physician is indicated.

Currently, with the exception of "the clearly defined instances of endocarditis and late prosthetic joint infections", there is no consensus among experts on the need for prophylaxis. The prophylactic use of antibiotics related to dental treatment should be avoided unless clearly indicated because the risk of widespread antibiotic resistance appears to be far more important than any possible perceived benefit.⁶⁶

Anti-Inflammatory Medications

Unless the patient has an allergy or stomach distress, non-steroidal anti-inflammatory agents (NSAIDs), such as ibuprofen or naproxen, are routinely prescribed just prior to the surgical procedure. It has been shown that the pretreatment use of ibuprofen decreases the onset and post-operative dental pain and is more effective than either aspirin or codeine. Since the inflammatory mediators do not peak until between 2-4 hours after surgery, it is not necessary to premedicate the patient with NSAIDs until within the hour, or two, before the procedure begins.⁵⁵ Under normal circumstances, the patient is kept on NSAIDs for no more than 5-7 days. Ibuprofen also inhibits platelet aggregation and blood clotting, but the effects are less pronounced than with aspirin.²⁵

Psychological Considerations

Approximately one person of every six is dentally anxious and must be considered.²⁰ Pain, both intra-operative and postoperative, is still one of the most common reasons patients fear about the dental visit.¹⁵ Studies indicate that dental anxiety is a complex fear with a number of components that can be dealt effectively by utilizing good communication with the patient.^{42,65} The most common causes of fear in patients occur when the dentist seems rushed (65 %), when the patient feels uninformed (50 %), when the patient worries if the local anesthetic will be effective (43 %), and when the patient's feelings are neglected (40 %).⁷⁰

During the microsurgical procedure, an important psychological consideration is ***do not*** tell the patient they "cannot move"! To an already tense and/or anxious patient, telling them they 'cannot move' could cause unnecessary worry, apprehension, or trigger any phobias the patient may have. The patient is coached, "Since we are working at such high magnification, and our view is very focused, if movement is necessary, just try to let us know in advance". In more than 500 surgeries the author has observed only two patients didn't hold adequately still during the entire procedure and that was because they had fallen asleep. Although the current hypothesis is that dental fears decline with age,⁴¹ all patients must be treated with tender, loving, kindness to achieve the best possible and atraumatic, clinical result.

Section 1: Preparation of the Patient, Surgical Team and Instruments

Preparation of the Patient

If there are no allergies or stomach distress, the patient should begin to take an anti-inflammatory (preferably 600 mg of ibuprofen QID) the day before the surgery, and maintaining that regimen for the next four, or five days. Starting the ibuprofen 24hrs before surgery maximizes its anti-inflammatory and analgesic effect.¹⁶ All necessary preoperative premedications and instructions are reviewed with the patient to be sure they were done appropriately and timely before the surgery appointment.

An important consideration, with the bearded male patient, is hairs that can obstruct the limited view the doctor has with the SOM. Since these can be very distracting under higher power, the patient should be advised to trim their mustache, or beard, before the time of the appointment. Often times the suture materials (6-0 & 8-0) are thinner than the facial hairs of the patient and can be very distracting during the suturing process, causing unnecessary stress for the surgical team. If there is any chance that these hairs can get in the way of good vision, they must be trimmed beforehand. During the middle of a surgical procedure is no time for the doctor to learn how to be a ??

The patient is seated and made as comfortable as possible. A small foam pillow is placed between the back of their neck and the headrest to give more support to the head and neck. The patient's chair should allow the patient to recline comfortably and even allow the patient to turn to one side or another if necessary. An articulating headrest is an asset, but it is best to have a form-fitting, foam pillow (Tempur™) to place beneath the back of the neck for support and comfort. Two common types of TEMPUR pillows are available to support the patient's neck (Fig. 34.9).

After briefly explaining to the patient the sequence of events, a sterile surgical towel is draped around the head and over the patient's eyes to maintain a sterile field and for protection from the bright light of the microscope or possible debris that may be dislodged during the procedure. Ideally, a monitor should be used throughout the duration of the surgery to record the pulse rate, diastolic and systolic blood pressure, and blood oxy-



Fig. 34.9. **A.** A small, straight Tempur™ pillow gives comfortable support for the neck. **B.** In certain instances, a “wrap-around” pillow of the same material, can give more support and a more comfortable patient.

gen saturation (Fig. 34.10).

After the patient is comfortably positioned in the chair, they are coached on how to make very small and very slow movements with their head if, or when, requested during surgery (Fig. 34.11). This is important since all movements, as viewed in the SOM, are greatly magnified in both distance and speed. The higher the magnification, the more exacerbated the movements can appear to the surgical team.

Preparation of the Surgical Team

The preparation of the patient not only takes the patient into consideration, but also the entire surgical team. The surgical team may consist of two or three persons, depending on whether the doctor utilizes a “four handed” or “six handed” approach to the microsurgical procedure. If the microscope is equipped



Fig. 34.10. **A.** The surgical patient is draped and connected to a monitor so their vital signs can be recorded during the entire procedure. **B.** Overall “room view” of patient prepared for apical microsurgery.



Fig. 34.11. Co-operation by the patient is coached on how to make small and slow movements when instructed during the surgical procedure.

with a beam splitter and no assistant’s scope is present, a monitor can be observed by one or more assistants.

The microsurgical protocol we routinely utilize involves three persons (“six hands”) to perform the procedure: the doctor as a “pilot”; the surgical assistant as a “co-pilot” using the co-observer scope for evacuation and retraction; and the “surgical director” as a “flight director”, using the video monitor as their main visual reference (Fig. 34.12).

The surgical assistant sees exactly what the doctor views and can very efficiently evacuate and retract when needed (Fig. 34.13). This assistant’s every move is totally under the control of the doctor. Therefore,



Fig. 34.12. Due to the precision involved, MicroSurgery is most efficiently accomplished as a six-handed procedure to reduce operator movements and achieve the team work necessary for a stress less event.



Fig. 34.13. The co-observer scope permits the surgical assistant to have the same view as the doctor and to be a much more efficient part of the surgical team.

training for this position can usually be accomplished in a very short time and with minimal “down-time”. However, once trained, they can be a tremendous help to the doctor and able to anticipate the next procedure to be performed, *if the protocol explained in this chapter is followed*.

The surgical director has an overview of the entire surgical team during the procedure and is the only one in position to keep everyone “flying in formation”. This assistant is responsible for handing instruments to both the doctor and the surgical assistant that is “in-the-scope” (Fig. 34.14). The patient can be considered the “passenger” on this first class micro-surgical flight.



Fig. 34.14. The second assistant (flight director) can hand instruments to either the doctor (pilot) or the surgical assistant (co-pilot) when needed, and has full view of the entire procedure, including the patient (passenger).

Now is the time for the surgical team to get comfortable and familiar with the position of the patient, the microscope, related equipment and instruments. The doctor needs to be the next to acquire a comfortable position. The surgical chairs should be ergonomically adjustable and have adjustable armrests to provide a fulcrum for the elbows. The arms serve as a reference point, or fulcrum, if the doctor has to reach for an instrument during surgery. Also, if the elbows are supported, it is easier to transfer even more support for the operator’s back and spine. After the doctor adjusts the SOM and is in position, the surgical assistant can now refine the focus of the co-observer scope and adjust their chair to a comfortable position. The mutual comfort of the patient, the surgical team, and the doctor is of the

utmost importance. Ideally, everyone on the surgical team should be sitting erect and comfortable. The microsurgical technique may take an hour, or more, so unnecessary movements, or adjustments for comfort’s sake by the surgical team during the operation could cause considerable inconvenience. Neither the doctor, nor the surgical assistant should have to remove their eyes from the oculars of the SOM during the entire operation. The task of directing the surgical procedure belongs to the surgical director. That person is the choreographer for the procedures to take place in the SOM; coaching and transferring instruments to both the doctor and the surgical assistant. It is the responsibility of the chief director (second assistant) that all possible surgical instruments have been previously organized for ease of access during the operation.

Preparation of the Instruments

Before the actual surgery begins (usually while allowing enough time for the local anesthetic to become profound), the notched ends of the 25 gauge Monoject Endodontic irrigating needles to be used on the Stropko Irrigators (Vista Dental, USA) are easily removed by rapidly bending them “back-and-forth” a few times with Howe pliers (Fig. 34.15). The endodontic irrigating needles are bent in the same configuration as the ultrasonic tip that is being used for the root-end preparation (REP) (Fig. 34.16, 34.17). Optimally, there are three Stropko Irrigators (Fig. 34.18): a) Dedicated “air-only” Stropko with a bent micro-tip for drying

b) Dual Stropko with air, water and a bent micro-tip

c) Dual Stropko fitted with a Blue Max tip (Ultradent), or Blue-Flo tip (Vista Dental) for more general flushing of the surgical area.

⇒**NOTE:** *When using the Stropko Irrigator, it is mandatory that the air and water supply pressure to the air/water syringes be regulated down so the forces of the expelled air and water are much lower than normal. The air pressure, using a 25 gauge needle, should be regulated to no more than 4-7 lbs./in² for surgery and the water pressure is correspondingly lowered (Irrigator Regulator Kit, Chapman-Huffman, USA, Part #: 17-050-00). This permits precise control of the water stream and prevents unwanted splashing during irrigation (Fig. 34.19).*

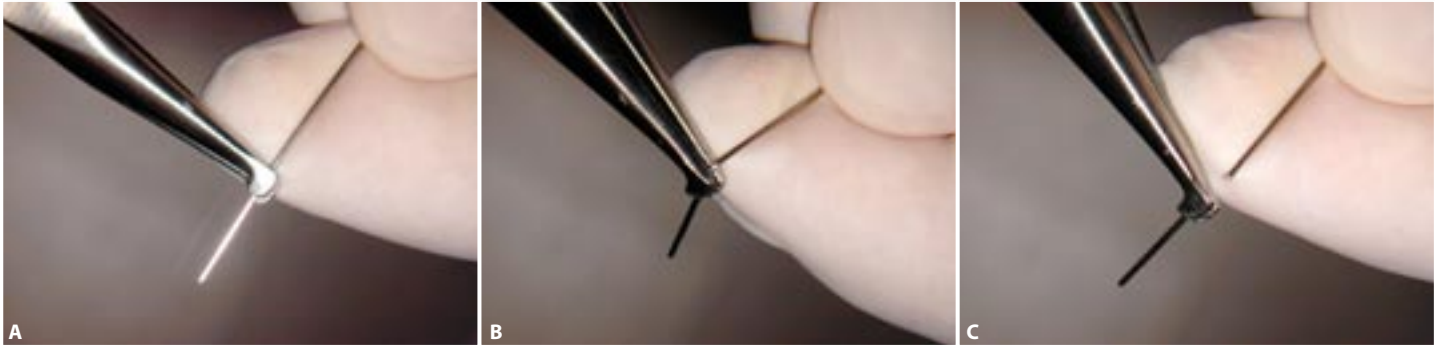


Fig. 34.15. **A.** The end 1/3 of the 25 gauge Monoject endodontic irrigating needle, containing the notched tip, is removed. **B.** Firmly grasping the end 1/3 of the needle with a Howe Pliers, then rapidly bending it back-and-forth is the quickest way to shorten it to the desired length. **C.** The notched end is removed and ready for bending.

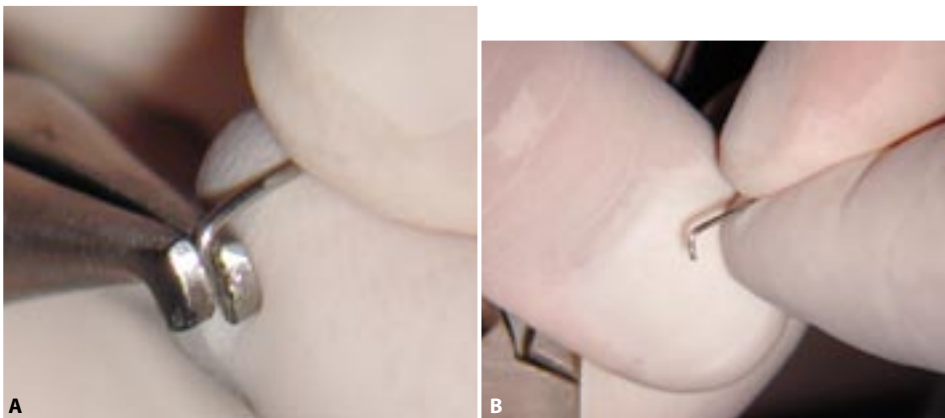


Fig. 34.16. **A.** Howe Pliers can be used to bend the tips of the irrigating needles in any desired angle to match the bend of the ultrasonic tip being used. **B.** Tip angle similar to angle of US tip.

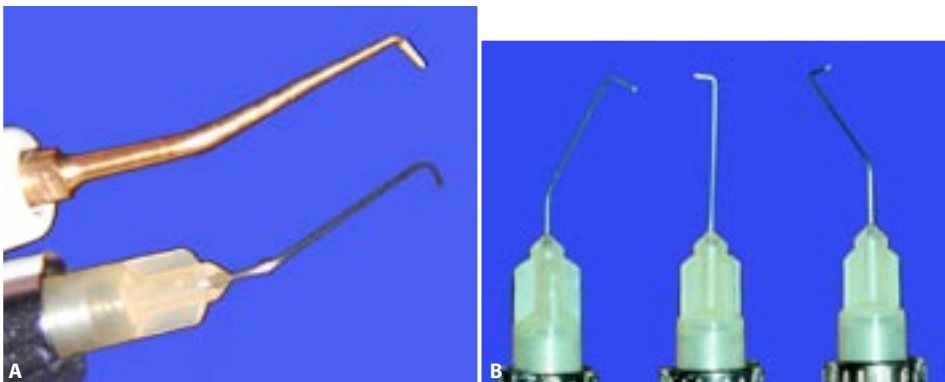


Fig. 34.17. **A.** Tip bent similar to the ultrasonic tip being used for the surgery. **B.** Variations of tips that have been bent to different angles to be used on the Stropko Irrigators.



Fig. 34.18. The ideal set-up of three Stropko Irrigators: **(A)** Dedicated "air only"; **(B)** Dual "air & water" needle size, and the **(C)** Dual "air & water" blue tip for more general irrigation.



Fig. 34.19. Chapman-Huffman regulator & gauge, is easily installed.

Since the lumen of the plastic, disposable, high-speed evacuator tips are small (Surg-O-Vac), extra tips should be readily available if one of them becomes clogged with blood or other surgical debris. Ideally, containers of NaOCl and hydrogen peroxide should be available in the set-up to allow the assistant to occasionally clear the evacuator hoses and system. However, if one of the evacuator tips becomes clogged, the chief assistant is in an excellent position to change the tips without disrupting or slowing down the surgical procedure.

The team now performs a final check of the entire surgical set-up and any corrections are addressed (Fig. 34.20).

If the patient is to have IV sedation, now is the time to begin the process.



Fig. 34.20. **A, B.** Surgical tray set-ups with all instruments sterile and ready for use.

Local Anesthesia

Warming the anesthetic syringe and carpule before injection relieves much of the discomfort usually associated with injections.¹³ A majority of the sensation the patient perceives is not from the small gauge needles used, but due rather to thermal shock from the cold, or room temperature anesthetic solution. Of course, preconceived “fear of needles” plays a part, but with gentleness, and understanding, it can usually be nicely overcome. The syringe should also be warmed to the same temperature as the anesthetic solution so it doesn’t inadvertently cool the anesthetic on the way to the injection site.

An easy and efficient way to warm both the anesthetic solution and the syringe is to use a common heating pad (Fig. 34.21). The temperature is set on “low”, and covered with a sterile towel. The carpules and the



Fig. 34.21. Placing the syringes and carpules on a common heating pad is a convenient and inexpensive method of warming the anesthetic before injection.

syringe can be placed on the towel, covered with another sterile towel, and be ready to use at the operator’s convenience. The warmed anesthetic of choice is injected very slowly to avoid any unnecessary “thermal shock” or trauma to the tissue.

After topical anesthetic is placed at the injection site(s), one 1.8 cc carpule of warmed 0.5% Marcaine (bupivacaine HCl) with epinephrine 1:200,000 followed by one 1.8 cc carpule of 2.0% Xylocaine (Lidocaine HCl) with epinephrine 1:50,000 are injected for the blocks and/or infiltrations necessary to achieve ade-

quate anesthesia. Normally, two carpules (3.6cc) are injected per block or infiltration. However, in the presence of inflammation, the pH of the site is lowered to 6.0 or less, resulting in a decreased effectiveness for any local anesthetic solution.²⁰ Much reconsideration must be given to the tendency to increase local anesthetic amounts in an effort to achieve profound anesthesia. It is the author's experience that profound anesthesia can often be a factor of time. Patients differ in their sensitivity to anesthetics and some may require more time than others to achieve maximal anesthesia. The doctor should never be in a hurry to begin the procedure before the patient is ready and profound anesthesia has been obtained.

Clinical studies have shown that even when a proper technique is employed, inferior alveolar nerve blocks (IANB) fail in approximately 30% to 45% of cases.⁵² In an attempt to minimize the IANB failure rate, the author routinely injects a small amount (about 0.3 - 0.4 cc) of 0.5% Marcaine lingual to the apex of the mandibular second molar. There is the possibility of a small branch of the mylohyoid nerve that enters into the mandible through the *foramen coli*, which can cause considerable amount of discomfort if present and not anesthetized. This may possibly account for some IANB failures.

A painless injection can be achieved by placing a topical anesthetic at the injection site and giving it enough time to be effective. For most infiltration injections, pressure anesthesia can be used effectively to eliminate any discomfort. To accomplish this, pressure is applied to the site with the tip of a finger while at the same time retracting the lip. The needle is placed into its final desired position and then the tissues pulled quickly down over the needle without moving the needle. A few drops of the warmed anesthetic solution are *slowly* injected, then aspirated to be sure of vascularization, and the rest of the carpule is dispensed *very slowly*. This technique is especially effective for all maxillary infiltration and mandibular anterior

injections. A mirror handle can be substituted in place of a finger in the smaller confines of the mouth for a nasopalatine, or greater palatine injection. As pressure is applied, the needle is inserted next to the pressure point and slowly dispensed into the tissues as the pressure is released. Mandibular block injections don't allow this technique, but if the other injection steps are followed, it can also be a painless experience for the patient.

Since local anesthetics are CNS depressants and can produce additive effects when administered in conjunction with other drugs which may have been given (IV sedation for example), the doses must be closely monitored according to the patient's body weight.⁴³ The surgeon must be constantly aware of the maximum allowable doses of the anesthetic(s) used. The milligrams per milliliter (mg/ml) have to be known and the total dosage should be recorded for each patient. A good way to remember the milligrams for a given anesthetic is each **1% of ANY anesthetic contains 10 mg/ml**. For example: a solution of 2% Lidocaine has 20 mg/ml. Therefore, a 1.8 cc carpule has 36 mg (20 X 1.8) of Lidocaine, and a 2.2 cc carpule has 44 mg. (20 X 2.2) of Lidocaine. A 1.8 cc carpule of 4.0% Citanest (Prilocaine) has 72 mg (40 X 1.8) of Prilocaine. The size difference of carpules available in different countries is significant, so it is much more accurate to use anesthetics and recording the milligrams, rather than the number of carpules used. The absolute maximal doses of the local anesthetics vary between 90 mg for Bupivacaine and 500 mg for Ultracaine as illustrated in Table 1. Great attention needs to be directed to the dose of local anesthetic given in relation to the patient's body weight and consideration given to other drugs prescribed and recently taken by the patient. If other drugs are given, the amount of the local anesthetic is reduced accordingly to avoid any unexpected or undesirable results.

Table I. Maximal recommended local anesthetic doses.^{21,43}

<u>Recommended safe limits</u>				<i>Absolute</i>	<i>1.8cc</i>	<i>2.2cc</i>
<i>Drug</i>	<i>Conc.</i>	<i>Mg/kg</i>	<i>Mg/lb</i>	<i>maximal dose</i>	<i>Carpules</i>	<i>Carpules</i>
Lidocaine	2.0%	4.4	2.0	300 mg	5.5	4.5
Mepivacaine	2.0%	4.4	2.0	300 mg	5.5	4.5
Prilocaine	4.0%	6.0	2.7	400 mg	3.5	3.0
Bupivacaine	0.5%	2.0	0.9	90 mg	6.5	5.5
Ultracaine*	4.0%	7.5	3.4	500 mg	5.0*	---

*Currently not available in the United States and is distributed in 1.7 ml cartridges

Epinephrine dosages also need to be considered, but the incidence of over dosage from the dental anesthetic cartridge is rare and almost always preventable. A vasoconstrictor, in combination with a local anesthetic, leads to more profound anesthesia and better control of bleeding during surgery so its use is encouraged.

There are two kinds of receptors we need to be concerned with when giving injections with local anesthetics containing epinephrine, or other catecholamines. In general, the smaller peripheral blood vessels in the oral mucosa have a high concentration of α_2 adrenergic receptors, whereas the blood vessels supplying skeletal muscles have a high concentration of α_1 adrenergic receptors. The α_2 receptors cause vasoconstriction, allowing better visibility during surgery. If the injection is given close to muscle, or muscle attachments, the α_1 receptors will cause vasodilation, complicating the surgical procedure and post-operative healing. Care given to these areas while giving injections, will not only enhance the anesthetic length of time and profoundness, but will have a favorable hemostatic effect during the surgical procedure.

If the anesthetic is inadvertently injected into a blood vessel, the epinephrine is carried to the heart. There it binds to the α_1 adrenergic receptors located in the muscles in the heart and causes increases in heart rate, cardiac contractility and peripheral resistance. *The use of an aspirating syringe is mandatory to prevent unnecessary and unfavorable reactions.* It is a good idea to aspirate at least a few times during each injection because of the possibility of a single blood cell blocking the narrow lumens of the smaller gauge needle commonly used today.

When a vasoconstrictor is not used, the anesthesia is less profound and of short time duration. Hemostasis is not well controlled, resulting in extremely difficult crypt management, which leads to impaired vision and unnecessary stress on the doctor, the surgical team and the patient. The patient can also release more endogenous epinephrine (and nor epinephrine) as a result of pain and anxiety than the exogenous epinephrine injected for the dental procedure.²⁰ But, more importantly, from a clinical point of view, if a patient can not have epinephrine used, hemostasis is compromised enough that the quality of the procedure will be jeopardized. After two such surgeries, my personal motto has become ***"No epinephrine, no surgery"***.

If the patient is more sensitive to epinephrine, or an overdose is given, the usual reaction is similar to the *"fight and flight anxiety response"* seen when a patient is startled suddenly. The patient usually appears very excited and will complain of palpitations, dizziness, tachycardia, weakness, hypertension, "shaky feeling", etc. The standard treatment is: 1) STAY CALM and assure the patient that the feeling will soon pass, 2) POSITION patient so the head is well above the feet, 3) have OXYGEN given to prevent dyspnea, and 4) MONITOR the patients vital signs. The overdose response to epinephrine is usually not severe, and quickly passes due to the rapid breakdown into inactive by-products by liver enzymes.²⁰

Using proper injection techniques and anesthesia protocol will prevent unfavorable reactions from even occurring. It is imperative that all dental injections given must incorporate aspiration techniques and be injected very slowly.

Hemostasis Staging

Using 1:50,000 Lidocaine, and keeping the bevel of the needle toward the bone, and directed toward the apex of the tooth, the hemostasis staging injections are given buccally in two, or three, sites over each surgically involved tooth (MB, B, DB) (Fig. 34.22). Insert the needle approximately 2 – 3 mm apical to the muco-gingival line, with the tip of the needle toward the direction of the tooth apex. This is repeated in 2 - 3 areas over each tooth that is involved in the surgical site. Slowly inject a few drops of the anesthetic until a slight "ballooning" and "blanching" of the tissue occurs. The blanching occurs primarily as a result of the vasoconstriction caused by the epinephrine on the alpha-receptors in the tissue (Fig. 34.23). In most surgical cases, this part of the hemostasis staging can be achieved with less than 1.8 cc (1 carpule) of solution. The "ballooning" of the unattached gingival tissue is important since it more clearly defines the muco-gingival line, allowing the operator more accuracy with the subsequent injections and better visualization in planning the incision (Fig. 34.24 A). As the anatomy and character of the tissue unfolds during the injections, the surgeon has a good opportunity to begin final planning of where the incision will be made (especially if an Oshenbein-Leubke flap design is to be used) (Fig 34.24 B).

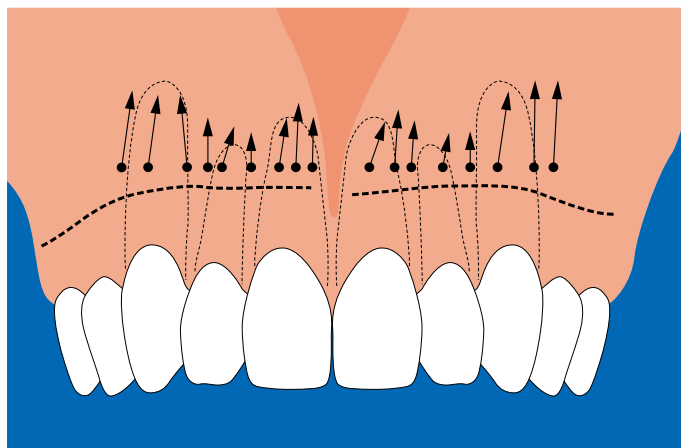


Fig. 34.22. Correct placement and direction for "hemostasis staging" injections.

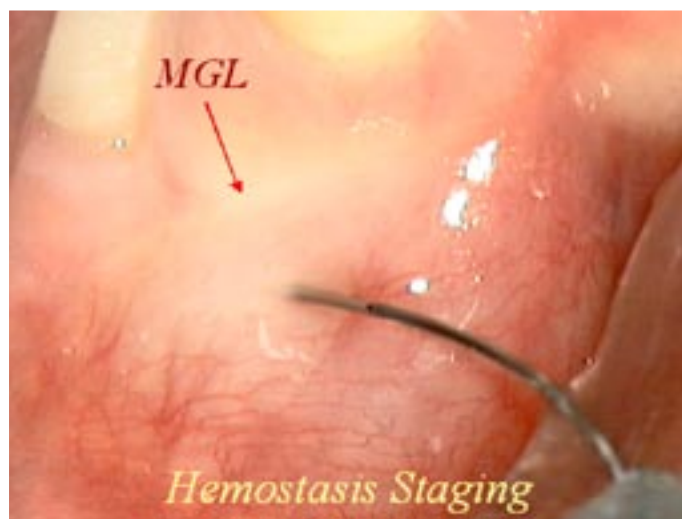


Fig. 34.23. The blanching and "ballooning" of the tissue clearly demonstrates the muco-gingival line.

Toilet and Stabilization of the Surgical Site

Approximately 8-10 thicknesses of 2" by 2" sterile gauze squares (4 or 5-2 X 2's folded over once) are used during the rather long surgery to help stabilize the jaws and maintain a comfortable position for the patient (Fig. 34.25). The mandible offers some anatomical challenges that are not a problem when doing periradicular surgery in the maxilla. In most instances, with the gauze in place, the maxilla and associated anatomy of the face (upper lip, nose, cheeks, etc.) prevents the operator direct access to the mandibular surgical site. It is usually necessary to leave the gauze out until after the incision is complete when operating on the mandibular teeth. The teeth closed down on the gauze prevent the effective use of the surgical instruments, especially the scalpel. In order to make a



Fig. 34.24. **A.** When done correctly, there is a distinct blanching of tissue due to the vasoconstriction of the vessels. **B.** "Hemostasis staging" complete, note how clearly the muco-gingival line is demonstrated.



Fig. 34.25. The jaws and teeth are stabilized when patient is biting on 4 - 2" X 2" gauze squares, folded in half.

sulcular incision in the mandible, the angle of the scalpel handle mandates the mouth is opened to varying degrees, depending on the external facial anatomy. If the patient is biting on gauze, it will be almost impossible to make a proper sulcular incision. On occasion the closed teeth may also interfere with instruments used for flap elevation. In most cases, the mandible does not present an obstacle when making the same incision around the maxillary teeth.

The patient has been instructed to rinse with 0.12% aqueous chlorhexidine gluconate (Peridex) beginning 24 hours before the time of the surgery. At the time of the appointment, and before the patient is seated, they are once again instructed to rinse with Peridex. Peridex has been shown to eliminate up to 85% of the bacterial flora from the surgical site and can prevent some undesirable post surgical infections. Its effect can last for four hours post-operatively and is considerably more effective than Listerine.³

The last procedure, before the incision, is to thoroughly clean the surgical area with a 0.12% chlorhexidine rinse (Peridex) to further control the bacterial flora. With the aid of the SOM, using a 3 cc syringe with a 25 gauge-irrigating needle, the entire surgical site is flushed again with Peridex (Fig. 34.26). Close attention is paid to the cervical and sulcular areas that generally harbor the most bacterial plaque. It is desirable to begin the procedure with the surgical area as clean of debris and free of plaque as possible. *A general rule is: do the toilet of the site and complete the incision in the mandibular surgical area **before** placing the folded gauze for stabilization. The maxillary teeth can usually be stabilized immediately **after** the injections for anesthesia.*



Fig. 34.26. Prior to the incision, the surgical site is rinsed with a 0.2% Chlorhexidine solution (Peridex).

After all is ready, the patient is instructed to close on the sterile folded gauze so just a small portion of the folded portion is protruding buccal to the line of occlusion. To prevent any debris from inadvertently entering the oral cavity during the surgical procedure, a single piece of sterile 2x2 gauze is also gently placed as far distal to the involved tooth (teeth) operated on as possible. The surgical site is now ready for the next important step in the procedure: flap design, incision, and atraumatic flap elevation.

Section 2: The Incision and Atraumatic Flap Elevation

Anatomical Considerations for Incisions: There are certain anatomic landmarks that have to be considered when planning the incision of the flap design. Fortunately, with little precaution, these areas can be avoided.

Inferior Alveolar Nerve (IAN or Mandibular Nerve)

When a radiograph indicates apexes is in, or near, the mandibular canal, the surgeon merely has to plan on making the access to the apex more coronal than usual. This will usually result in a more acute bevel than desired, but is far less of a problem than if the mandibular nerve was damaged. Root resection must be accomplished before the apical extent of the root is determined. By resecting the apex first, there will be more room to perform a delicate curettage and lessen the chances of nerve damage. If a lesion just touches the nerve sheath, the mere act of “peeling it off” of the sheath can cause a temporary paresthesia.

The patient should be advised *before the surgery begins* that there is a possibility of a temporary paresthesia post operatively. Clinical experience shows that if there is a paresthesia, the patient feels a “tingling” sensation at the corner of the mouth on the same side the surgery was done on. Often times it is described as “that feeling you get when the local anesthetic is starting to wear off”. Typically, within a few weeks, or months, the paresthesia disappears and the patient can’t recall when it did disappear. If the patient was told beforehand, there is usually no “excitement” about the event. If by chance, the patient was not advised of the possibility of a temporary paresthesia, it is very important to not get excited.

Mental nerve

The mental nerve is probably the most common clinical concern whenever performing apical surgery on the mandibular posterior quadrant. Even when doing apical surgery on a lower cuspid, the doctor has to be keenly aware of its presence when retracting the flap. Special care must be given especially when making a vertical releasing incision in the general area. Sometimes it is possible to palpate the mental foramen. The location of the mental foramen is best done radiographically by taking at least two different angles of the area. If there is any doubt of its location, great care has to be given to avoid unintentional damage to the mental nerve. It is possible to be very conservative while making the releasing incision. A “cautious” incision can be made, slight elevation of the tissue done for vision, and incision extended if there is no foramen seen. This process can be repeated until the incision has been made to the desired depth.

If possible, it is a wise clinical protocol to locate the mental nerve during flap reflection (Fig. 34.27). It is usually located between, and slightly



Fig. 34.27. The mental nerve is best avoided if its location is determined at the first opportunity during surgery.

inferior to, an imaginary line drawn from the apices of the mandibular bicuspids. The mental foramen first appears as a “dimpling” of the cortical plate of bone that “exits” to the distal. Once located, care must be exerted to not place any pressure on the emerging mental nerve with the retractor, or any other instruments.

As with the mandibular nerve, if the apex having the apical surgery is near the mental foramen, the access will need to be made slightly more co-

ronal than usual and the bevel slightly more acute. Both of these procedures need to be done with the mental nerve and foramen kept well in mind.

Greater palatine artery

Of all the horror stories ever heard, the accidental severing of the greater palatine artery has to be the most fearsome! Since the artery enters the oral environment through the greater palatine foramen, located at the junction of the alveolus and the palate between the maxillary second and third molar, this situation usually presents itself doing surgery on a maxillary molar with a palatal approach. This is another very good reason to perform apical surgery on the palatal roots of maxillary molars using the Buccal or Trans-sinus Approach. It is very difficult to get to the greater palatine artery when coming in from the buccal.

In the event the artery is severed, it can be cauterized with a “ball” electrosurgical tip. Since the artery is fairly large, an attempt to cauterize it with heat (Touch & Heat or System B) would probably be futile. If an electro-surgery unit is not available, finger pressure can be applied to the area for 5 to 10 minutes and the artery will usually seal itself off and the endodontic surgery can proceed.

The Incision

The incision is made using a CK2 microsurgical blade (SybronEndo). With the smaller size of this blade, very accurate incisions can be made that have a cleaner cut than those of the much larger BP #15 or BP #15C blade (Fig. 34.28). A good idea is to consider the suturing while designing the incision. Sometimes just



Fig. 34.28. Comparison of BP #15C blade to a CK2 micro-surgical blade.

a small variation in the design of the incision can make a significant difference in the ability to get closer, more rapid approximation, with less trauma, when attempting closure of the surgical flap. The endodontic surgeon is usually working with relatively healthy tissue and no attempt should be made to remove, or alter the periodontium. This is especially applicable when making a full sulcular flap. All flaps should be full thickness, including the periosteum and the overlying mucosa. The split thickness flap is to be avoided as it is the most traumatic and healing is compromised.²⁰ All flaps, regardless of design, should extend to the mesial of the second tooth anterior to the root that apical surgery is being performed on (*See illustrations in following discussions of different flap designs*). In some cases, the operator may want to extend the flap even further. The very minimum extension would be to the mesial of the tooth positioned anterior to the tooth root that the apical surgery is being performed on. The length of the flap will not be a factor in healing or post-operative discomfort, so the flap design should be extended sufficiently to allow for adequate vision, atraumatic elevation and retraction. In general, the larger the flap, the better the access and the easier atraumatic flap management becomes. The flap design differs depending on the integrity of the bone over the roots, the amount and nature of the attached gingiva, the anatomy of the jaw, and the absence, or presence, of fixed dental appliances. Basically, there are two flap designs:

Full Sulcular Flap: This flap design is the flap of choice in the posterior quadrants, or if esthetics is not a concern in the anterior region (Fig. 34.29). If there is little attached gingiva, a concern about the possibility of a dehiscence over the root(s) of the tooth

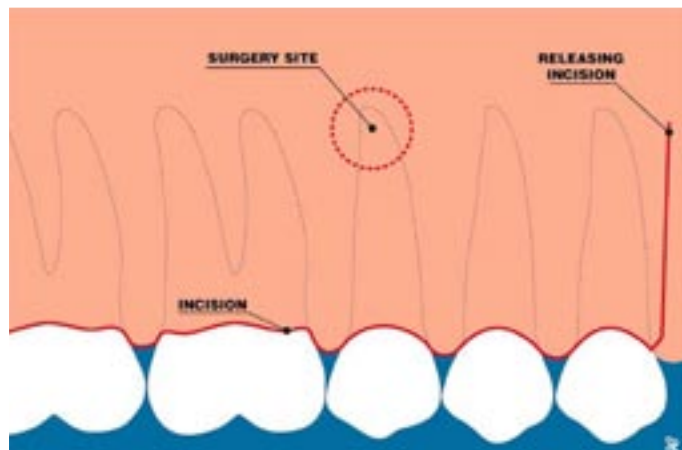


Fig. 34.29. Full sulcular flap design should extend to the mesial of the 2nd tooth from the surgical site.

being operated on (a vertical fracture), the full sulcular flap allows the most freedom of treatment options. In the event one of the roots of the tooth is determined to be non-salvageable and needs to be resected, the flap can easily accommodate reapproximation after the procedure. Guided tissue regeneration can also be accomplished more conveniently when the full sulcular flap is utilized. Even if the entire tooth has to be extracted for some unforeseen reason, the full sulcular flap will still suffice for closure. In other words, this flap design is the most forgiving of all, since adequate and uncomplicated reapproximation can be achieved under almost all circumstances.

Another important advantage of a full sulcular flap is the ability to fully visualize the emergence form of the root(s) we are performing apical microsurgery on. Often, the involved teeth are crowned and the true incline, or emergence, of the long axis of the root(s) is misrepresented. Radiographs are an essential aid to visualize the direction of the root, but if the angulation is not correct, they too can be misleading to the surgeon. With the entire facial surface of the bone exposed, any aberrations in the direction of the roots are readily observed.

The incision, for the full sulcular flap, is made through the gingival crest adjacent to the tooth surface. The scalpel should be approximately parallel to the long axis of the buccal surface of the tooth, and follow the curvature around the cervical of the teeth involved in the surgical area. The operator should attempt to incise the tissue through the sulcus to the osseous crest of bone, leaving the healthy gingival attachment intact when possible (Fig. 34.30). The sulcular incision should extend into the mid-coll area since there is no collateral circulation between the lingual/palatal tissue and the buccal/facial tissues.

Submarginal Flap: (Luebke- Ochsenbein): This flap design is only used when there is an adequate amount of attached gingiva present and the periodontal probing is within normal limits so the incision can be made over intact and healthy bone. The thickness, nature, and location of attached gingiva are important considerations as to whether a full sulcular or Luebke-Ochsenbein flap is used. In any case, enough of the attached gingiva is left at the coronal margin of the flap (at least 2 mm) to allow the operator to easily reposition the flap. This is especially applicable in the anterior sextant when it would be desirable to avoid the cervical tissue covering margins of crowns that have been placed for cosmetic purposes. The Luebke-Ochsenbein flap is not likely to change the sulcular

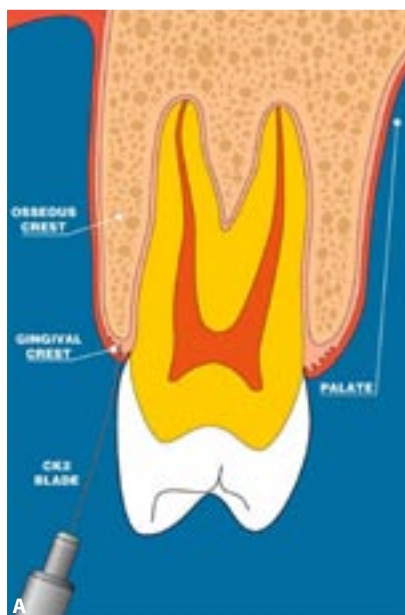


Fig. 34.30. **A.** Full sulcular flap with the incision made to the osseous crest, X-section view. **B.** The micro scalpel must be held nearly parallel to the long axis of the tooth in order to incise at the osseous crest.

integrity of those cervical tissues and therefore is more forgiving to the surgeon.

The incision design should have rounded scallops that generally follow the architecture of the teeth and allow for easy repositioning upon completion of the apical microsurgical procedures (Fig. 34.31).

On occasion, the design of the flap may be a combination of the above two designs. The presence of dental appliances, restorations, quality of attached gingiva, etc., can sometimes indicate a different placement of the incision. The surgeon should not hesitate to modify the incision design to accommodate the current situation presented.

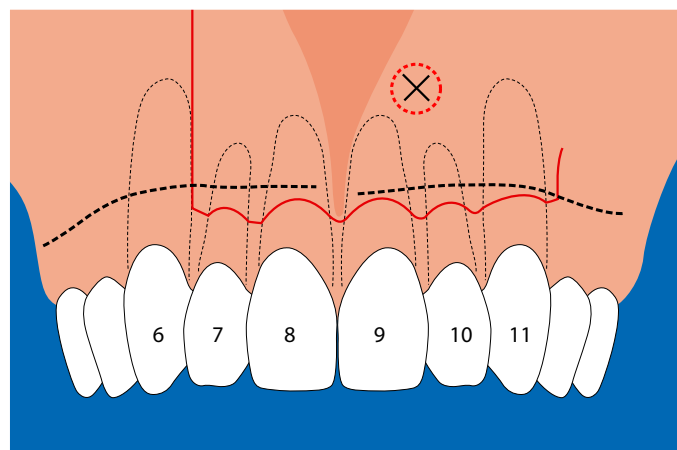


Fig. 34.31. Submarginal, Muco-gingival, or Luebke-Ochsenbein Flap Design is usually used when cosmetics is an issue in the anterior segment.

Currently, the *Full Sulcular* and the *Luebke-Ochsenbein* are the only two types of flaps recommended for use in apical surgery. The *Semilunar Flap* and the *Split Thickness Flap* are not used since healing is compromised, and proper access is difficult to achieve and maintain with both designs. It is also considerably more difficult to achieve definitive reapproximation of the incision edges when suturing either of these two flap designs, so scarring is commonly seen after healing (Fig. 34.32). The disadvantages of these flap designs suggest they not be used.²⁰



Fig. 34.32. Note the scarring from surgery done 5 years previously & no evidence of scarring from recent surgery.

Depending on the number of releasing incisions, the flap design will be either triangular, or rectangular. If a single releasing incision is used, it is a triangular

flap design (Fig. 34.33). If two releasing incisions are used, it is a rectangular flap design (Fig. 34.34). On occasion, the flap may be “stretched” upon retraction, and a small incision may be necessary to “relax” the flap. This “releasing” incision is usually very small and

seldom need to be sutured after surgery (Fig. 34.35).

All releasing incisions are made parallel to the long axis of the teeth. This is important because the blood supply to the area is also parallel to the long axis (Fig. 34.36).

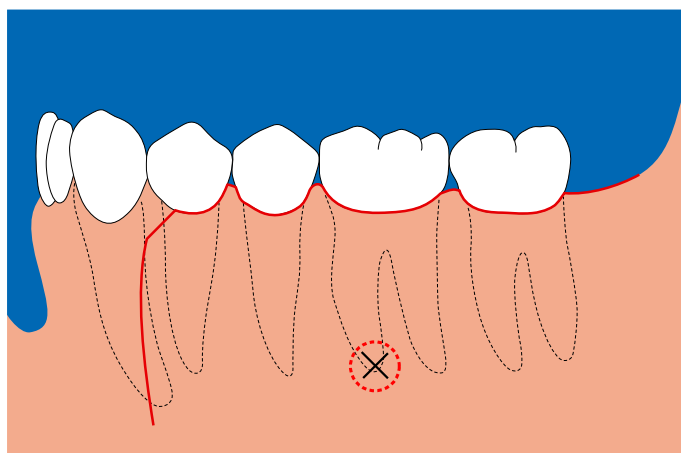


Fig. 34.33. The Triangular Flap design, with a “single releasing” incision.

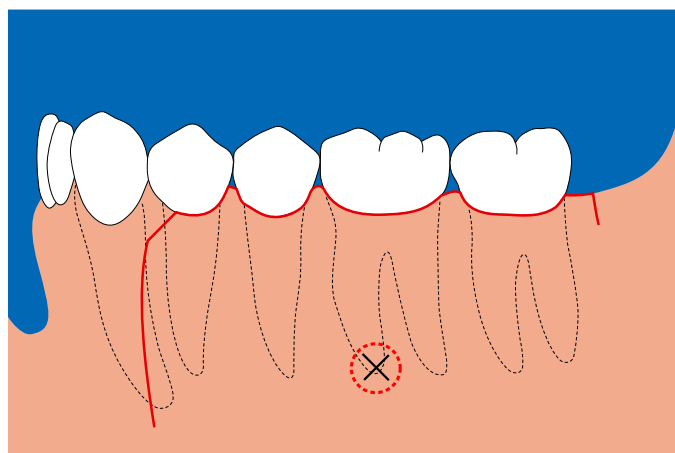


Fig. 34.35. A Triangular Flap design demonstrating a “relaxing incision” to the distal, so the flap will not be stressed.

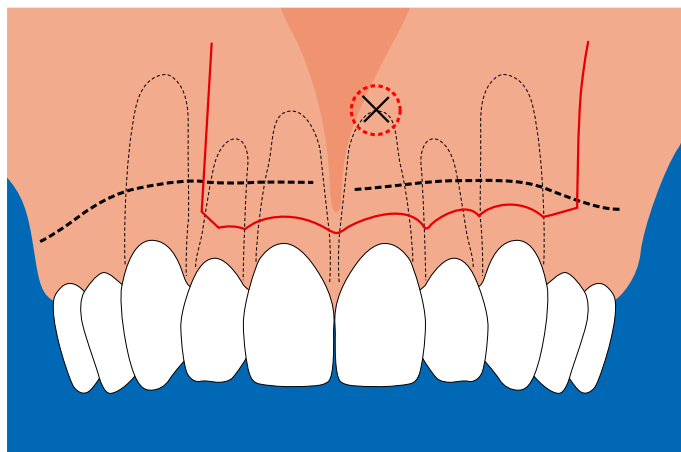


Fig. 34.34. The Rectangular Flap design, with two “releasing” incisions.

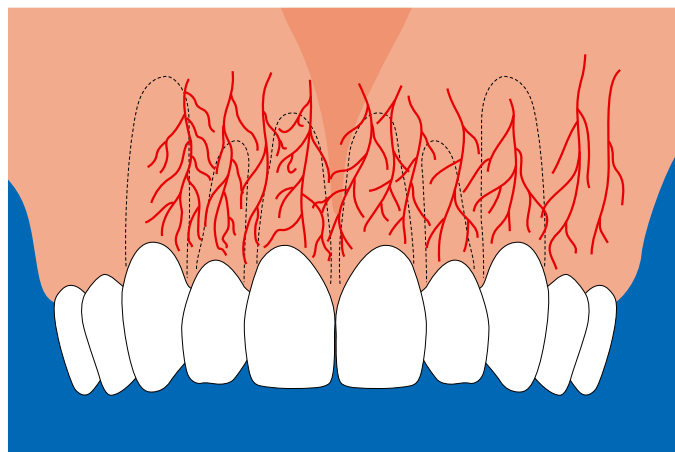


Fig. 34.36. The blood supply is parallel to the long axis of the roots of the teeth and should be preserved to enhance rapid healing.

If a “wide base” type flap is made, some of the blood supply to the coronal tissue is interrupted and the flap has a greater tendency to shrink, so healing is compromised and more likely to result in healing by secondary intention. The purpose of the releasing incision is to allow atraumatic reflection of the flap. The surgeon must always be ready to eliminate any tension on the flap by increasing the length of the releasing incision, or adding an additional releasing or relaxing incision. Stretching of the flap can cause injury and tearing of the tissues, compromise the healing of the site, and result in unnecessary discomfort for the patient. If the flap appears to be stressed, a small “relaxing” incision can be made to eliminate the tension. These “relaxing” incisions are usually no more than 3-4mm in length, but can effectively ease the tension sometimes created during the retraction process.

Reflection of the Flap

After the incision is completed with the desired flap design, the next step is to reflect the flap of tissue and gain access to the surgical sight. The reflection of the flap has to be done in an atraumatic manner to insure uneventful post operative healing. Unless the flap is treated in a gentle manner, more swelling and discomfort will result post operatively for the patient.

The atraumatic reflection of the flap is easily accomplished using sharp periosteal elevators: either a one of the Molt elevators, or a selection from a set of four Ruddle elevators (SybronEndo). The Ruddle Elevators (Fig. 34.37) are available in right, or left, and all periosteal elevators are available in small and large sizes. The basic difference between the Molt and the Ruddle elevators is the Molt is a straight instrument with no right, or left curvature (Fig. 34.38). No matter what elevator is used, it is important they be kept sharp so the periosteum can be gently “dissected” from the osseous surface, rather than be “torn” from it. The working ends of these instruments are gently inserted into the releasing incision, beneath the unattached gingival tissue and as far apical as the tissue will allow (Fig. 34.39). The motion is a gentle “up-and-down” (apical-to-coronal) movement between the osseous surface and the overlying periosteum of the unattached gingival portion of the flap. Maintaining the same motion, the instrument is moved slowly toward the same apical position at the other extent of the flap, gently dissecting the periosteum from the osseous surface. The sharp elevators cleanly dissect the over-lying tissue from the osseous surface and there



Fig. 34.37. Set of 4 Ruddle elevators. The working ends of the elevators are basically of the same design and are intended to dissect and lift the periosteum from the osseous surface.



Fig. 34.38. The Molt elevator is similar in design to the Ruddle and is shown inserted under releasing incision of the flap; also atraumatically dissects and elevates the periosteum. Courtesy of Dr. Gary Carr, San Diego, CA, USA.



Fig. 34.39. The first step of flap elevation is to insert the periosteal elevator under flap at the site of the releasing incision.

should be no tearing. If done correctly, the attached gingival (coronal) portion of the flap will be easily released from the bone. It is not uncommon, usually on the posterior segments of the mandible, to encounter a very small ledge of bone associated with the muco-gingival line (MGL). This can be difficult and the operator may have the tendency to be more forceful in the reflection process. But, a little extra time taken at this point, will reap rewards in the healing process. Once the beginning portion of the MGL is separated from the osseous surface, the remainder of the flap will release quickly and uneventfully (Fig. 34.40). *Always keep in mind: the elevation process is a dissection to gently separate the layers.*

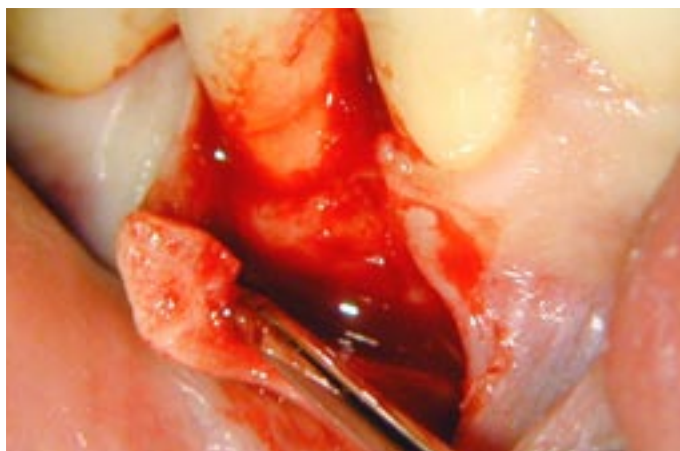


Fig. 34.40. The atraumatic reflection of flap involves no tearing of tissue and begins at the vertical releasing incision.

On occasion, when there is a chronic lesion, such as a sinus tract, that had broken through the buccal plate of bone, and is an integral part of the overlying tissues (Fig. 34.41), a scalpel, or sharp tissue scissors

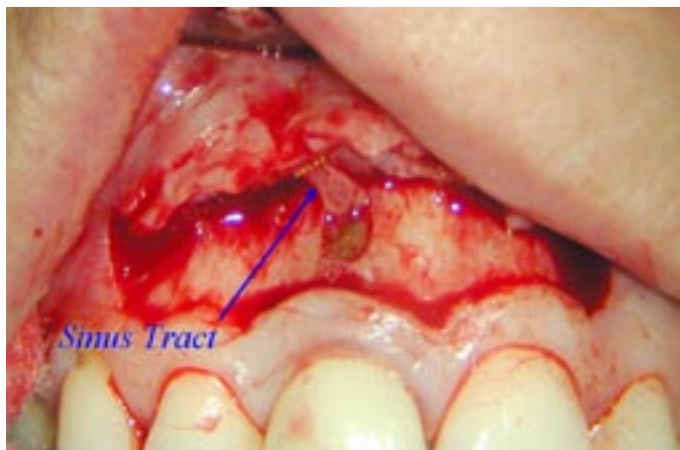


Fig. 34.41. The sinus tract is severed as close to the level of the osseous surface as possible to maintain a normal flap thickness in the area.

must be used to separate the tract and lesion from the flap, to permit continuation of the reflection process. Every attempt is made to sever the fistulous tract at the level of the osseous surface. If the above concepts are followed, the flap can be atraumatically raised without even touching the incision.

The undermining, atraumatic reflection of the flap is a major contributor to the rapid healing response normally observed only 24 hours post operatively. It is important the approximating surfaces of the flap are never touched after the incision is completed, so there are no crushing or ischemic injuries to inhibit or retard the healing process. The periosteal elevator should be kept sharp so dissection can be accomplished while separating the periosteum from the bone surface. An instrument such as the old wax spatula shaped periosteal elevator has no place in the armamentarium of the endodontic microsurgeon.

Once the flap is gently and cleanly reflected, any "tissue tags" should be left intact as they will aid in the healing process. It is not necessary to clean the flap and exposed bone since these efforts are time consuming and can be traumatic to both the hard and soft tissue. Studies have shown that these "tissue tags" aid in the healing process and should be left alone.²⁷

Atraumatic Flap Retraction

The retraction of the flap should also be accomplished in a gentle and atraumatic manner. The most common cause of post-operative pain and swelling arises from impingement of the tissue during the retraction process (Fig. 34.42). An effective way to achieve atraumatic retraction is to prepare a groove in the cortical plate of the bone, well apical to the surgery site (Fig. 34.43). This allows a definite place for the retracting instrument to seat into and be positioned without slipping (Fig. 34.44). In this way, there is a definite rest for the instrument and the flap doesn't inadvertently get caught beneath it (Fig. 34.45). A surgical length # 8 round bur, on a high speed hand piece that does *NOT FORCE AIR* into the surgical site is used for this purpose. The surgical hand pieces are available as the Impact Air 45 (Star Dental, Lancaster, PA, USA), or, the Innovator (SybronEndo) (Fig. 34.46). Note: A high-speed hand piece that has air escaping from the working end should never be used because of the potential danger of air embolism.

Satisfactory retraction can be accomplished using any of the numerous retractors on the market (the author uses the Carr, Rubinstein or Minnesota retractors).

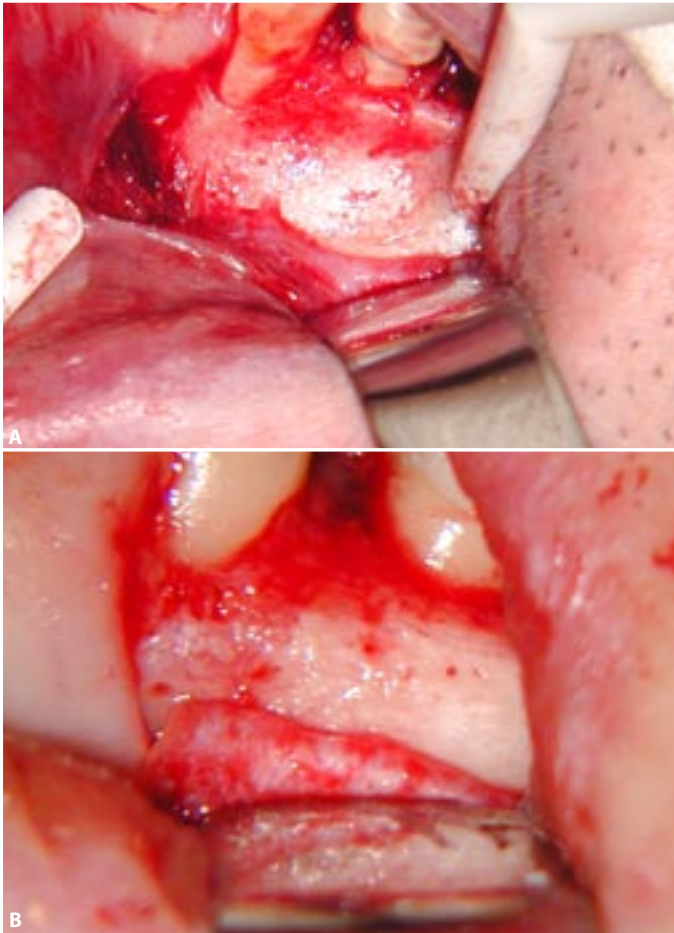


Fig. 34.42. **A, B.** Impingement of the flap by the retractor is a common problem and the most common cause of post operative pain and swelling.

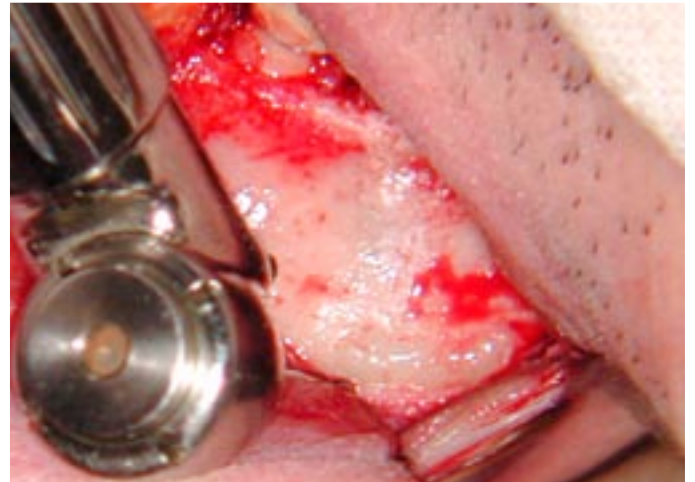


Fig. 34.44. The groove in the cortical plate of the osseous surface is ready to receive the end of the retractor.



Fig. 34.45. The retractor is securely placed into the groove and the flap is atraumatically retracted.



Fig. 34.43. A #8 round bur is used to prepare a groove for the end of the retractor, to assist in avoiding tissue impingement during surgery.



Fig. 34.46. The Impact Air 45, or, Innovator, surgical handpiece, with fiber optics, enhances efficiency, safety, and vision.

The specific retractor is chosen that will best maintain clear visibility to the surgical area and is comfortable in the doctor's hand. A # 2 front surface mouth mirror can even be used to advantage for retraction and vision when working at the apices of mandibular teeth. A broader groove is necessary so the mouth mirror will fit into it and prevent the flap from being impinged upon. The assistant can then use a Stropko Irrigator, with a Blue plastic tip, to alternately spray water and air on the mirror surface while the doctor is preparing the apical retroprep. The vision is greatly enhanced because the doctor can see the ultrasonic tip and the beveled end of the root very clearly.

If there is any tension on the flap, the vertical releasing incision can be extended, or an additional releasing, or relaxing, incision can be made at the other side of the flap. In any case, it is imperative the operator keeps in mind there should be no tension, or stretching of the tissues during the retraction process. Dr. Berman, an older, retired general surgeon and one of my dental school instructors, would begin each surgery lecture with the words, ***"Treat the tissues with tender loving kindness and they will respond in a like manner"***. How many times I have heard those very words while performing apical microsurgery. It should be a gentle technique.

Section 3: Access and Crypt Management

Access

After the properly designed flap has been atraumatically reflected and retracted, the access preparation is ready to begin. There are three surgical length burs that can accomplish all that is required in apical microsurgery; the Lindemann bone cutting bur, the # 6 or # 8 Round bur, and the # 1170 or # 1171 tapered-fissure bur (Fig. 34.47). Some important considerations before beginning the access are:

1) How much bone exists on the buccal aspect of the root being surgerized?

If there is total dehiscence, guided tissue regeneration, or a multi-disciplinary approach has to be considered. Ideally, there should be at least 2-3 mm of healthy, intact crestal buccal bone remaining after the access preparation is completed.

2) How much of the apex can be beveled, or resected?

In the normal case, there is an adequate amount of root length to work with. But, if there is an exceptionally long post extending closer to the apical terminus

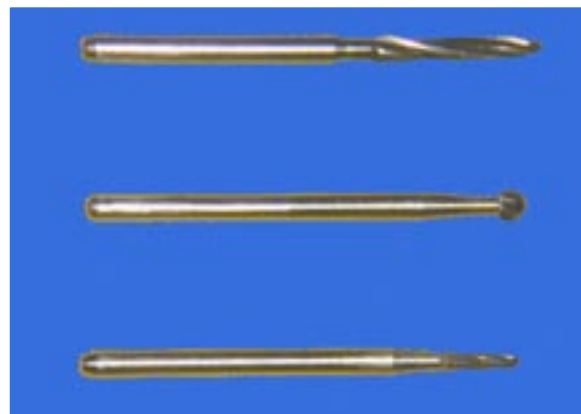


Fig. 34.47. Only three essential surgical length burs will accomplish all that is necessary to achieve an efficient root-end resection and refinement of the root-end bevel. (top) Lindemann bone cutting bur, (middle) #6 or #8 Round bur, and (bottom) 1170 or #1171 tapered-fissure bur.

than desired, not as much of the apex can be resected (Fig. 34.48). If the tooth is short, or the periodontal bone level is less than desired, a more conservative amount of apical root structure should be remo-

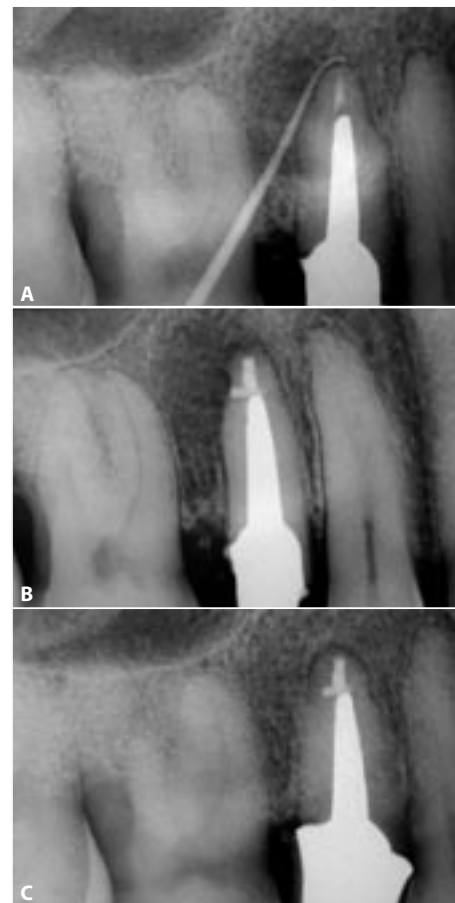


Fig. 34.48. **A.** The gutta-percha point indicates the presence of a fistulous track. The tooth has a lesion on the distal aspect and a long cast post: surgery is indicated but not much of the root apex can be resected. **B.** Post-operative radiograph: two retrofills have been placed, one at the apex and one in the lateral canal, responsible of the lateral lesion. **C.** Two year recall. (Courtesy of Dr. Arnaldo Castellucci).

ved to preserve as much crown/root ratio as possible. Fortunately, the SOM allows the operator the luxury of being ultra conservative when necessary. There are basically two different ways to begin the access:

1) Estimate the amount of the apex to be resected. The length from the occlusal surface can be determined in many ways: a radiograph taken with a small piece of foil or gutta percha over the approximate position of the apex; a marked instrument or sterile wooden stick, etc. Then, with a Lindemann bone-cutting bur remove the apex and prepare the access opening in one general step. If there is any portion of the apex remaining in the crypt, it is removed with a curette and the access is, more or less, complete.

2) Estimate the location of the apex (Fig. 34.49), and with a # 8 surgical length, round bur, slowly and gently remove the bone overlying the buccal surface

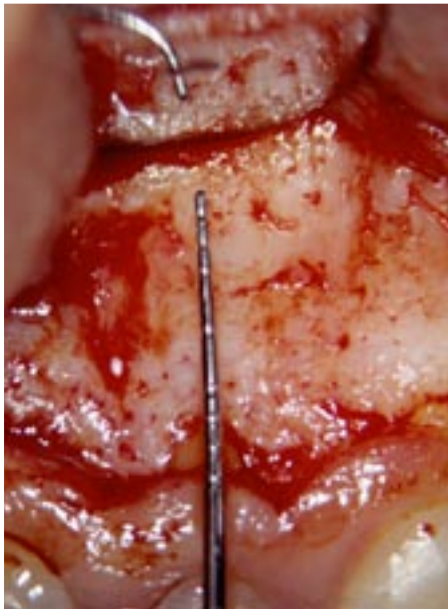


Fig. 34.49. The periodontal probe is indicating the estimate location of the root apex, previously measured on the preoperative radiograph. (Courtesy of Dr. Arnaldo Castellucci).

of the lesion and/or root. When the buccal surface of the apex is uncovered, bone is removed until the general parameters of the crypt are established and the general position and curvature of the root apex is readily observed.

After completion of this step, the lesion of endodontic origin (LEO) can usually be removed with a curette and the entire apex exposed. The use of a small, double-ended Jacquette will often facilitate the removal of the entire LEO in one piece, ready for a biopsy. If the lesion is more palatal, or lingual, the ro-

ot apex may prevent the necessary access for curettage and will have to be partially beveled, or resected as part of the access process. A thorough curettage is important because it is the first stage of achieving hemostasis within the crypt. In general, if all of the granulation tissue is removed, the amount of hemorrhage will be greatly reduced, the management of the crypt is more easily accomplished and good visibility can be restored. This technique takes more time but this is my technique of choice. I want the visibility, accuracy, and the predictability of knowing the exact status of the surgical area.

If the surgeon feels it necessary, the lesion may be prepared for a biopsy at this time. If the cause of the lesion is not positively identified, or if the previous treatment did not respond in the manner expected, a biopsy should always be performed whenever tissue is removed from the body. However, the tissue can be macroscopically studied with the SOM and all factors can be weighed to determine the necessity of a biopsy. The appearance of the osseous surface in the crypt after curettage can be a fairly accurate indication of the type of lesion removed. A smooth walled crypt would indicate a non-invasive and benign lesion of endodontic origin (LEO). This, along with an obvious reason for endodontic failure, may preclude the necessity of a biopsy. A biopsy should always be performed if the lesion appears to be invasive, or does not satisfy all the requirements of the typical apical LEO. ***The safest and most thorough recommendation is to routinely perform a biopsy on any tissue that has been surgically removed. The routine biopsy provides the level of treatment that assures everything is done for the patient that is humanly possible.***

The opening dimension of the access varies depending on several factors:

1) The size and position of the lesion. If the lesion is larger, the access will, of necessity, be larger in order to perform a complete curettage.

2) The position of the apex determines the size of the access. The more lingual the apex, the more overlying bone has to be removed and the larger the access has to be for good visibility.

3) The access has to be large enough to allow the instruments room to prepare the apical canal system without inhibiting their freedom of movement. The larger the instruments used, the larger the access must be. Using instruments specifically designed for microsurgery can allow a more conservative access opening.

4) The thickness of overlying bone is also important. If the buccal plate is thick, a wider access is necessary to eliminate a “tunnel effect”. There must be enough of an access to permit the entrance of light into the surgical crypt so as not to compromise the surgeon’s vision.

5) The apical curvature of the root may sometimes require a larger access opening. A good example is often seen in the maxillary laterals. However, once the apical 3 mm is apicect and the bevel completed, the curvature left is usually not as abrupt and difficult to work with.

6) A very large lesion that has penetrated the osseous surface may leave an opening with very thin edges. These should routinely be “blunted” so the edge is definitely healthy bone. Doing this defines the access opening clearly and helps prevent possible sequestration during post-operative healing process.

Crypt Management

The management of the crypt is one of the most important steps and the operator should take as much time as necessary to achieve the desired result. After all granulation tissue, and other debris, have been thoroughly removed from the crypt, hemostasis is usually achieved just from the “hemostasis staging” infiltration injections given at the beginning of the procedure. In such cases, only an appropriately cut piece of Telfa, lining the floor of the crypt, is necessary. However, this is not always the case and even slight bleeding must be addressed to preserve optimum visibility. A clean and relatively dry crypt is essential for good visibility and proper use of retrofill materials. Never proceed until total management of the crypt has been accomplished.

Numerous methods have been suggested to achieve hemostasis in the periapical surgical crypt. Ferric sulfate (FS), calcium sulfate (CS), bone wax, epinephrine impregnated cotton pellets (EPIDRI or Rancelets by Pascal), CollaCote, lasers,⁴⁶ Telfa Pads, Tissue Goo, rubber dams,¹⁹ and others have been described in the literature. Of these, FS, CS, epinephrine pellets, and Telfa pads appear to have gained the most favor and are the most commonly used, effective, commercially available, agents for crypt management. Their use will be addressed and the doctor can decide which works best for them. The remaining techniques won’t be discussed because they have disadvantages that can create difficulties by complicating the procedure itself, and/or the

post-operative sequela. The most important purpose for crypt management is to maintain visibility and moisture control so the surgery can be performed more efficiently and the retrofill materials can be used predictably to effectively seal the canal system.

Ferric sulfate (FS)

There are several popular forms of Ferric sulfate (FS), each having different concentrations: Monsels Solution has a concentration of 72% FS, and Cutrol is 53% FS. ViscoStat (Ultradent) is a 35% FS concentration and is available in a convenient Tissue Management Kit. Ferric sulfate achieves hemostasis by agglutination. Small micro-applicators are bent so they can more easily be directed into the crypt and are used to place the FS (Fig. 34.50 A). A good idea is to place a few drops of the FS into the small end of a dappen dish, so just part of the micro-applicator tip (Ultradent, Vista) can be dipped and the amount of the solution precisely controlled. A very small amount of FS is placed on the micro-applicator (Fig. 34.50 B). The FS is placed on the end of a micro-applicator tip and gently wiped into the crypt to achieve hemostasis. Immediately upon contacting blood, a thick, brownish-black coagulum results and bleeding stops almost instantly (Fig. 34.50 C). The excess coagulum can be easily removed with a clean Micro-applicator (Ultradent) tip. Once the solution is in the crypt, and more FS is necessary for hemostasis, additional “dipped” micro-applicators can be used. If there is excess solution already present in the crypt a fresh, clean applicator can be used to remove it. In this manner, excess coagulum is avoided and toilet of the crypt involves less effort. Gentle flushing with a Stropko Irrigator fitted with a 25ga needle or a Blue tip, can be used very effectively to flush out any excess coagulum and readily evacuated by the surgical assistant (Fig. 34.51). It is important to use the FS solution as sparingly as possible and be careful it is only confined to the interior of the crypt. It has been shown that post surgical problems are directly related to the amount of FS used.³⁸ The coagulum, resulting from the use of the FS solution, has to be fastidiously cleaned out of the crypt after the completion of the surgery. If the coagulum is removed, its use has not been shown to affect the healing process.³¹

CAUTION: All FS must be kept well within the confines of the crypt. Due to its extremely low pH, the FS will quickly cauterize any tissue it comes in contact with and create instant hemostasis! The buccal

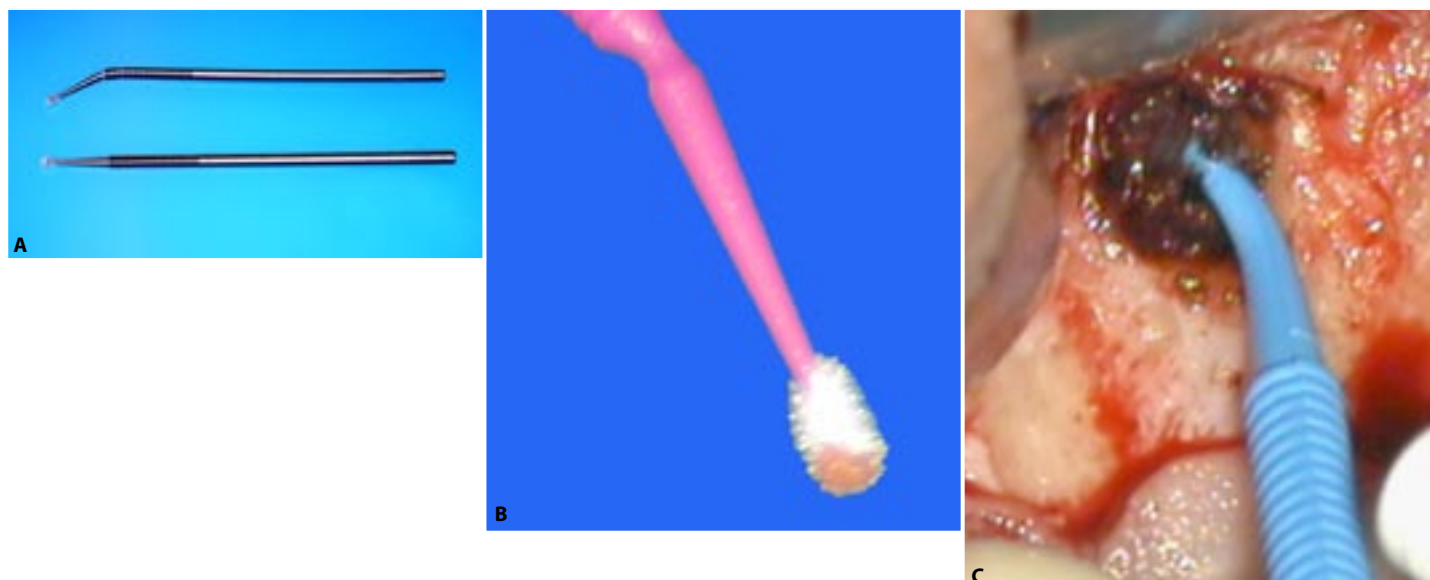


Fig. 34.50. **A.** The various micro-applicators can be bent at any angle to more efficiently enter the crypt. **B.** Only a very small amount of FS needs to be placed on the tip of the micro-applicator to achieve hemostasis. **C.** A thick, dark brown coagulum develops when FS comes into contact with blood.



Fig. 34.47. Only three essential surgical length burs will accomplish all that is necessary to achieve an efficient root-end resection and refinement of the root-end bevel. (top) Lindemann bone cutting bur, (middle) #6 or #8 Round bur, and (bottom) 1170 or #1171 tapered-fissure bur.

plate of bone, the periosteum, soft tissue, and the Snyderian membrane should always be avoided! It is important to keep in mind “If a little bit is good, a lot is not better!” Use only small amounts on the end of a micro-applicator because a small amount goes a long way!

Slight hemorrhaging

If the crypt exhibits only slight hemorrhaging, the tissue surface of an appropriately cut piece of Telfa can be lightly streaked with FS and pressed into the base of the crypt for a short period of time until the hemorrhaging is completely controlled. As soon as there is complete control of the crypt, the Telfa should be removed and replaced with a fresh piece so there is as much “white” surface as possible to facilitate light reflection and enhance vision. Other agents that can be

easily used for slight hemostasis are 25% aluminum chloride (Tissue Goo), ViscoStat (Ultradent), Epidry pellets (Pascal) and Calcium Sulfate (Figs. 34.52 A, B).

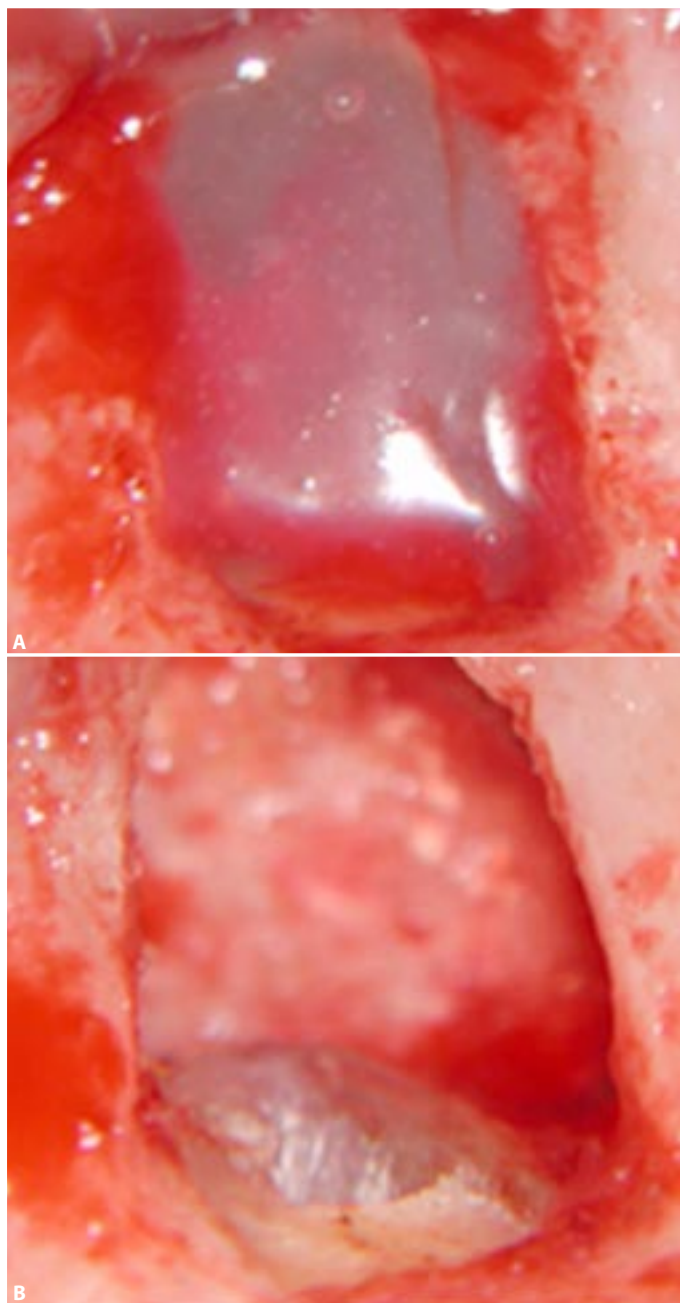


Fig. 34.52. **A.** Tissue Goo is a viscous gel containing 25% Aluminum chloride. It is easily introduced into the crypt to provide hemostasis when there is a slight amount of hemorrhaging present. **B.** The Tissue Goo rinses readily from the crypt, leaving a clean surface.

Moderate hemorrhaging

For moderate hemorrhaging, the FS is applied with a micro applicator (Ultradent, Vista) directly to the problem area in the floor of the crypt. Several applications may be necessary, but avoid the tendency to “over-use” the FS. The process is repeated until the bleeding is controlled and the resultant coagulum can be removed and visibility restored. Again, keep in mind that only a small amount is necessary and if there is some FS coagulum remaining in the crypt, use a plain applicator to gently wipe the problem area. One of the Blue plastic tips, fitted on a Stropko Irrigator, is an effective way to gently flush the coagulum out of the crypt.

Calcium Sulfate

Calcium sulfate (CS), more commonly known as Plaster of Paris, has been used with good success in dentistry. Periodontists, Oral Surgeons, and Implantologists have all used CS with favorable results⁴⁹ and, unlike FS, it is biologically compatible. CS is a good hemostatic agent, inexpensive, sterilizable, easy to manipulate in the crypt, sets relatively fast, and readily cleans out of the crypt after use. An excellent choice for this use is CS available from J. T. BAKER, Division of Malinckrodt Baker, Inc., Phillipsburg, NJ USA. Dental impression plaster can also be used if the above is not available. If FS has previously been used in the crypt management procedure, CS can still be used after as much of the FS has been cleaned out as possible.

Small amounts of CS (approximately 2-3 Grams) are placed into glassine envelopes for sterilization and storage. The envelopes are then placed into a conventional microwave oven for 30 seconds at the highest power setting. It has been shown that the microwave is an effective means of sterilization.⁵ The effectiveness of microwave sterilization is also related to the dryness of the object(s) to be decontaminated.³³ The low water content of CS lends itself to be effectively sterilized. The glassine envelopes containing the CS can also be sterilized in a conventional oven at 200° F for 1 hour. Care must be taken to keep the temperature below 450° F or the hemihydrate form can be converted to an anhydrate and the setting time will be significantly increased.

The second assistant can mix the CS with a cement spatula in the large end of a dappen dish. After mixing is complete, the CS is handed to the doctor on the end of the cement spatula, or in a

Dovgan Calcium Sulfate Carrier (Fig. 34.53 A), for placement into the crypt. Using this carrier, the delivery of the CS is efficient and well controlled (Fig. 34.53 B). The crypt is filled to the level of the buccal plate of bone (Fig. 34.53 C).



Fig. 34.53. **A.** The Dovgan Calcium Sulfate Carrier (Quality Aspirators, USA). **B.** The Calcium Sulfate is delivered in the crypt. **C.** The crypt is filled to the level of the buccal plate of bone.

NOTE: Before the CS is set, the wooden handle of a sterile “Q-Tip” can be used to effectively manipulate the CS if necessary. The CS does not stick to the wood and the manipulation is simplified as a result. A thick mix

of CS is used because the blood proteins can greatly inhibit the set of the CS. Therefore, it is always advantageous to work in as dry a bone site as possible so the setting time is more predictable. If a thick, and fast-set, mix is used, the CS will set before significant blood proteins can infiltrate the cement.⁵⁴ In the event ferric sulfate is used in the crypt prior to the placement of the CS, there has been no adverse affect observed on the CS by the FS, as long as there is no excess residue left in the crypt.

Once the CS is placed into the crypt, a gloved finger can apply pressure as setting occurs. It is important to allow the CS to set completely *before* carving to expose the apex of the tooth. This helps prevent the inadvertent dislodgement of the CS and the “seal” is maintained. The barrier provided by the CS enables complete control of moisture contamination and permits the use of bonding techniques. After the CS is completed, it can be “carved-back” with a bur or discoid instrument, re-exposing the beveled apex and the ultrasonic root-end procedures can resume. Two important advantages of using CS for crypt management are the hemostatic properties and its white surface that helps to reflect light for better vision. Upon completion of the surgery, the CS is easily removed with an ultrasonic fitted with almost any tip that can reach into all areas of the surgical crypt. Since the CS is completely removed after surgery, most forms of Plaster of Paris can be used for hemostasis and crypt management.

Since some forms of CS (Plaster of Paris) have fillers such as silicates and/or cellulose (wood) fibers, it is imperative that all non medical grade CS is removed that was used for crypt management. If the CS is to be used as a barrier, or for guided bone regeneration (GBR), and allowed to remain after suturing, the requirements are different and only medical grade CS should be used. Medical grade CS is available in under the brand names BoneGen by Ortogen Corp (USA) and SurgiPlaster by ClassImplant (Italy). For minor hemorrhage control, a light layer of medical grade CS can also be “dusted in” with a powdering device (powderlator) and then, if desired, the rest of the crypt can be filled with mixed CS. *Just remember only medical grade CS can be left in the crypt after surgery.*

Another method of crypt management used by many surgeons is epinephrine coated cotton pellets (EPIDRI by Pascal). The pellets are placed into the crypt until hemostasis is achieved. Then all but the first pellet, or two, is removed to allow the surgeon to finish root end procedures. *Note: Always keep an*

accurate count of the pellets used and be sure to **remove all cotton fibers from the crypt** after root end procedures are completed! *Extreme caution is to be used when operating near the maxillary sinus, or other vital structures, so they aren't inadvertently pushed into an undesirable area.*

If hemorrhaging occurs on the surface of the exposed buccal plate, a Touch'n Heat (SybronEndo), set at its highest temperature setting, can effectively achieve hemostasis by heat cautery. The assistant, especially if they are utilizing a co-observer scope, using a small evacuator tip, helps locate the exact source of the bleeder (Fig. 34.54 A). Once the source of the bleeder is located, the tip of the Touch'n Heat can be used to effectively cauterize it (Fig. 34.54 B). The "nuisance" bleeder is successfully eliminated (Fig. 34.54 C). *NOTE: Although the "nuisance" bleeder has been stopped, there is a probability that another will begin hemorrhaging. But, normally, it is not an inconvenience and the microsurgical procedure can continue without stress.*

Severe hemorrhaging

On rare occasions, severe hemorrhaging can occur, either as a result of inflammation, a severed interdental artery, remaining infected tissue, or a compromised clotting mechanism. At any rate, when the blood flows faster than the evacuator can remove it, there is good reason for a little excitement and fast action! The first thing done is to apply pressure over the crypt with a finger. This will stop the hemorrhaging long enough to **calmly** prepare the next few steps. First, in a low and controlled voice, instruct the assistant to insert a bigger tip into the evacuator and hold it close to the crypt. If after removing your finger, the hemorrhaging has not subsided, quickly replace your finger over the crypt as before. Now have your assistant take a large piece of sterile cotton roll, and make a "plug" large enough to completely fill the crypt. If no anatomical landmarks (nerve canals, maxillary sinus) are of an immediate concern, lightly streak the tissue surface of the cotton wad with Monsels Solution and insert it into the crypt, holding it firmly in place with your finger for a minute or so. It is a good idea to take a radiograph at this time, to verify the anatomical landmarks (E.I. the sinus, mandibular canal, mental foramen, etc.), so the operator can be more confident of the relationship of the access crypt to them. After a few minutes, the cotton "plug" can usually be safely re-

moved and the surgery can proceed without undue concern. If there is much excess dark colored coagulum as a result of the use of ferric sulfate, remember that gentle irrigation with the Stropko Irrigator will remove most of it. The above technique has worked all three times the author found himself in that situation. In two of the cases an interdental artery was the cause and the other was severely inflamed granulation tissue remaining in the crypt. After the retrofill is completed it is important to thoroughly curette the osseous surface of the crypt, removing as much of the ferric sulfate coagulum as possible, therefore re-establishing blood flow into the crypt and allowing uneventful healing to occur.

After the hemorrhaging is completely controlled, and the crypt relatively cleansed of remaining coagulum, a fresh piece of Telfa should be placed over the internal surface of the crypt. Or, if CS is used, it can now be placed. Keep in mind when using the SOM that light and dryness are the most important factors for good visibility. Using fresh pieces of Telfa, or a new application of CS, will help a great deal to keep the crypt dry, and provide a white surface that will reflect light and provide a brighter and cleaner surgical field (Fig. 34.54 D). Once the crypt management is completed, the doctor can proceed to refinement of the bevel and preparing the root-end preparations (REP) with confidence and good visibility. At the end of this step, all hemorrhaging should be controlled; the grossly resected apical end of the root should be easily seen; and the floor of the crypt covered with a clean, white piece of Telfa or the clean, white surface of CaSO₄. During a microsurgical procedure, it is important to maintain as white a background as possible so more light is reflected within the crypt and the operator's vision is enhanced.

Section 4: The Root End Bevel (REB) and Root End Preparation (REP)

The Root-End Bevel (REB)

The amount, or degree, of the root-end bevel (REB) is of utmost importance and should be precisely planned in advance. The overall crown/root ratio, presence of posts or other obstacles, the root anatomy, and the periodontal status of the tooth have to be considered. Canal system ramifications occur 98% of the time in the apical 3 mm. Of roots that have two canals, the

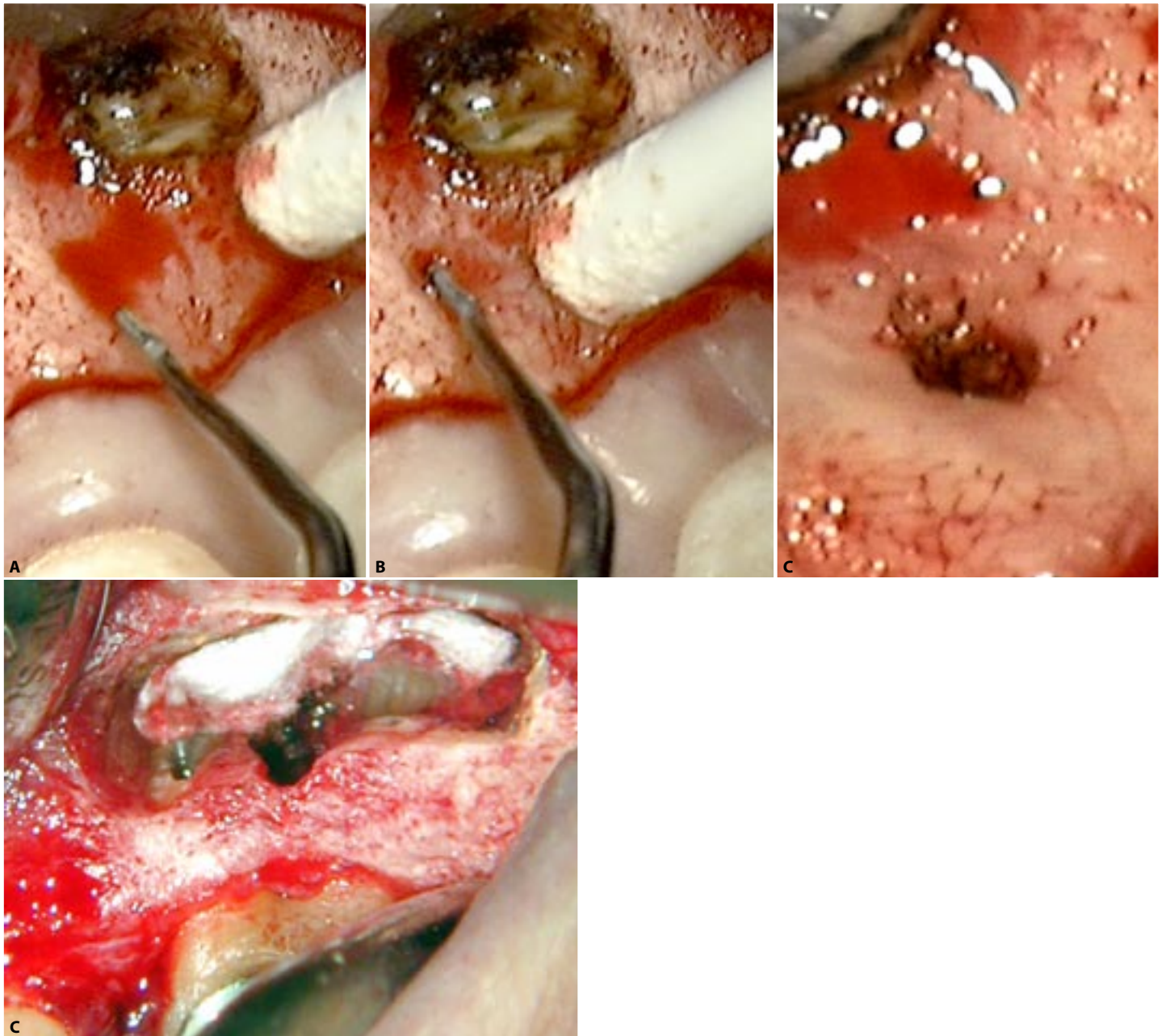


Fig. 34.54. **A.** The assistant, utilizing the co-observer scope, can gently evacuate the bleeding point so the surgeon can “pin-point” the exact source of the bleeder. **B.** Using a very hot instrument, or a Touch-n-Heat with the setting on 10, the bleeder can be cauterized to stop the bleeding. **C.** The result is an effective way to eliminate a “nuisance” bleeder. **D.** After crypt management is complete, a clean, white piece of Telfa, cut to the right size to fit the floor of the crypt is placed to reflect light and provide better vision to the surgeon.

4 mm level will have complete or partial isthmus 100% of the time.⁷¹ If the REB is long (traditionally 20–45°) an excessive amount of root structure would have to be removed to include the apical 3 mm on the palatal, or lingual part of the root apex (Fig. 34.55 A). It is for this reason; the operator tendency is to leave more of the palatal, or lingual, aspect of the root intact and have a more increased risk of completely missing some important palatal or lingual anatomy (Fig. 34.55 B). The “shorter” bevel, as close to 0° as possible, the lingual 3 mm is easily removed; more root structure can be conserved, improving the crown/root ratio (Fig. 34.55 C). With

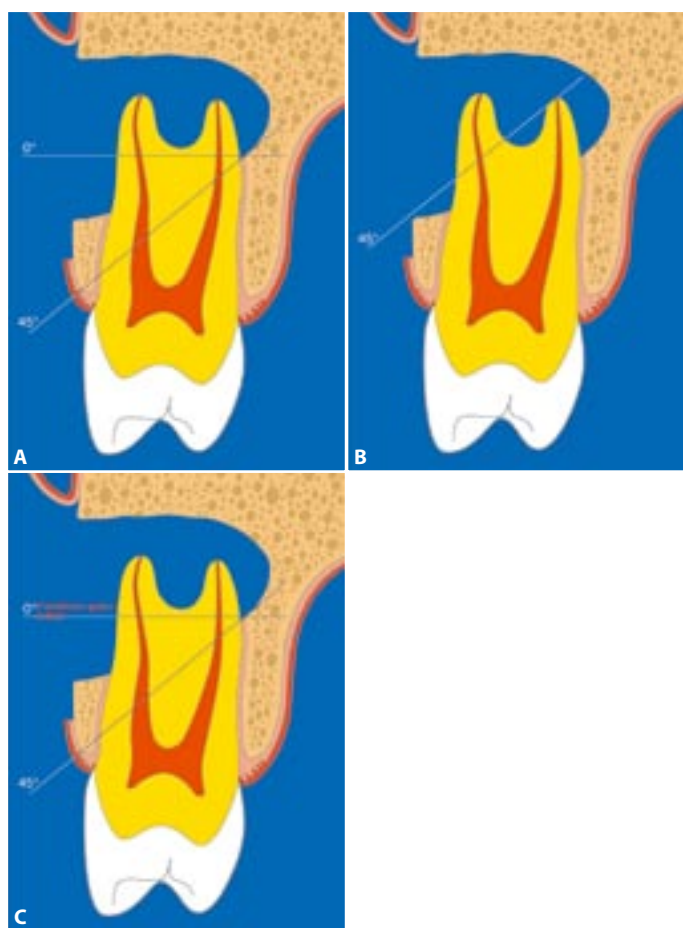


Fig. 34.55. **A.** To address the same lingual anatomy as the “short” bevel, the “long” bevel would destroy much more root structure. **B.** By being more conservative with a “long” bevel, the important lingual anatomy is easily missed. **C.** Comparison of the “long” versus the “short” bevel clearly demonstrates the advantages of the “short” bevel.

a long bevel, there is also an increased risk of completely missing some important palatal or lingual anatomy. This is especially true if the operator is in any measure trying to be conservative, in order to preserve as much crown/root ratio as possible. Clinically,

the “long” bevel disorients the surgeon, creating a spatial orientation problem that is generally impossible to overcome regarding the true long axis of the canal system (Fig. 34.56 A). Since it is difficult to visualize the long axis of the tooth, the resultant retroprep will usually not be within the long axis of the canal and the root-end preparations (REP) will be inclined more to the lingual, or palatal, than intended. Once the “long” bevel is done, the operator is handicapped. A typical example is this SEM of a lower first molar that was done on a dried mandible and then extracted to show the disorientation that occurs with the “long” bevel (Fig. 34.56 B). The tendency while doing the REB

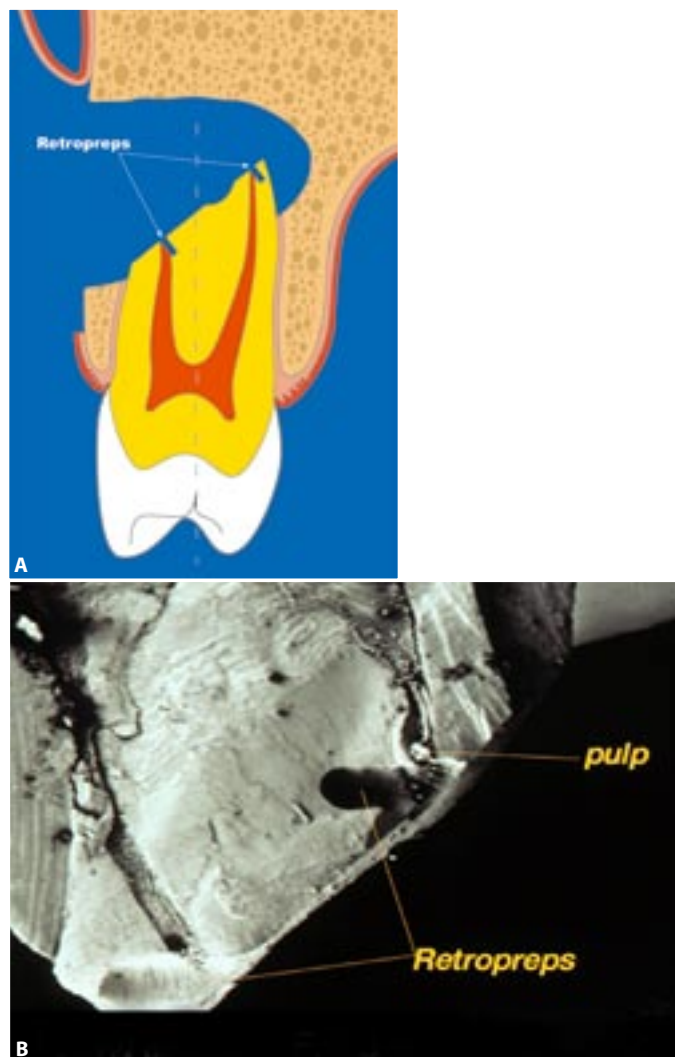


Fig. 34.56. **A.** The “long” bevel creates a nearly impossible orientation of where the true long axis of the tooth really is. As a result, the REP are always more to the lingual than intended. **B.** This SEM of a lower 1st molar, clearly demonstrates the danger the disorientation the “long” bevel creates for the operator. This case was prepared on a dried mandible (Courtesy of Dr. Gary Carr).

is to be as conservative as possible in both the “short” and the “long” REB. In general, after watching, or performing hundreds of Apical Microsurgeries, the most dangerous bevels are the “long” and “conservative” ones (Fig. 34.57 A). This concept is of utmost importance to think about while doing apical surgery and is one of the primary reasons the REP perforates, on occasion, to the lingual or palatal (Fig. 34.57 B).

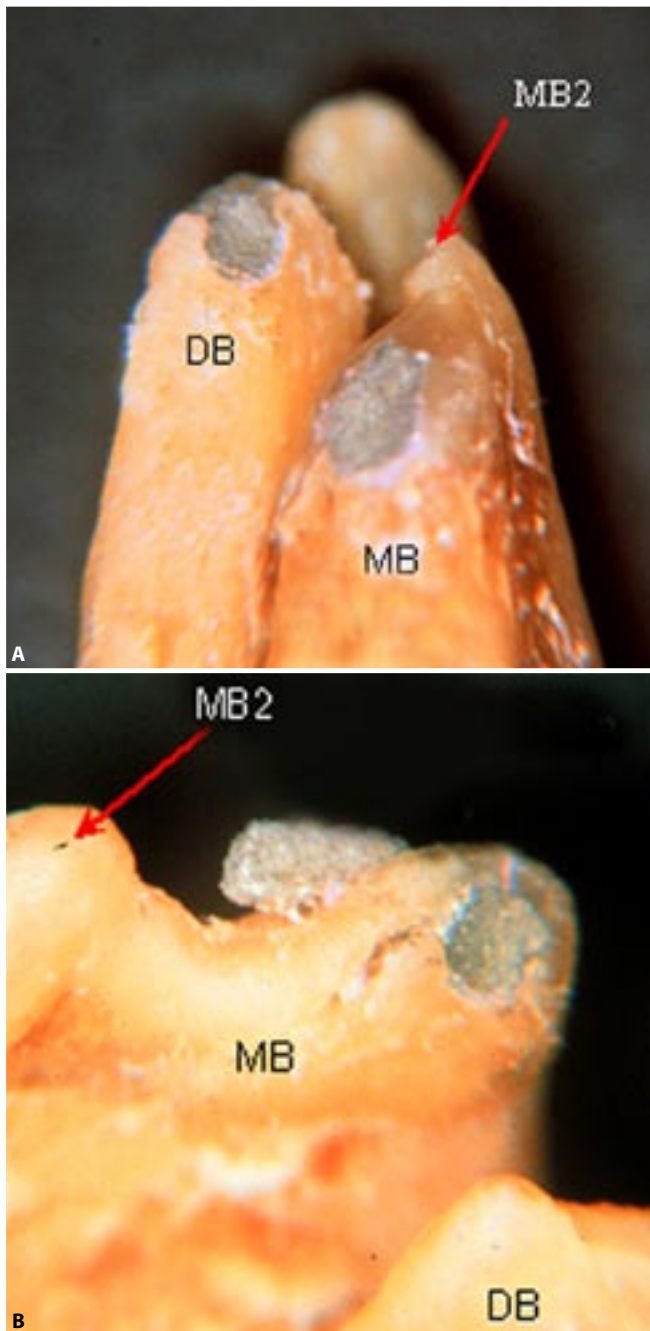


Fig. 34.57. **A.** The operator was trying to be conservative with a “long” bevel and thought the apex of the MB apex of this max. 1st molar was adequately sealed. **B.** The palatal anatomy, the MB2, was completely missed and the MB1 was inadvertently perforated to the lingual.

Another consideration for the “short” bevels, are the cavo-surface marginal dimensions (*bet you haven't heard that term in awhile!*) of the prep will be considerably decreased, and therefore, allowing an easier and more predictable seal of the margins (Fig. 34.58 A). The “long” bevel has a much greater cavo-surface margin to clean and contend with. As a result there is more possibility of leakage and less predictability for a successful, long term result (Fig. 34.58 B).

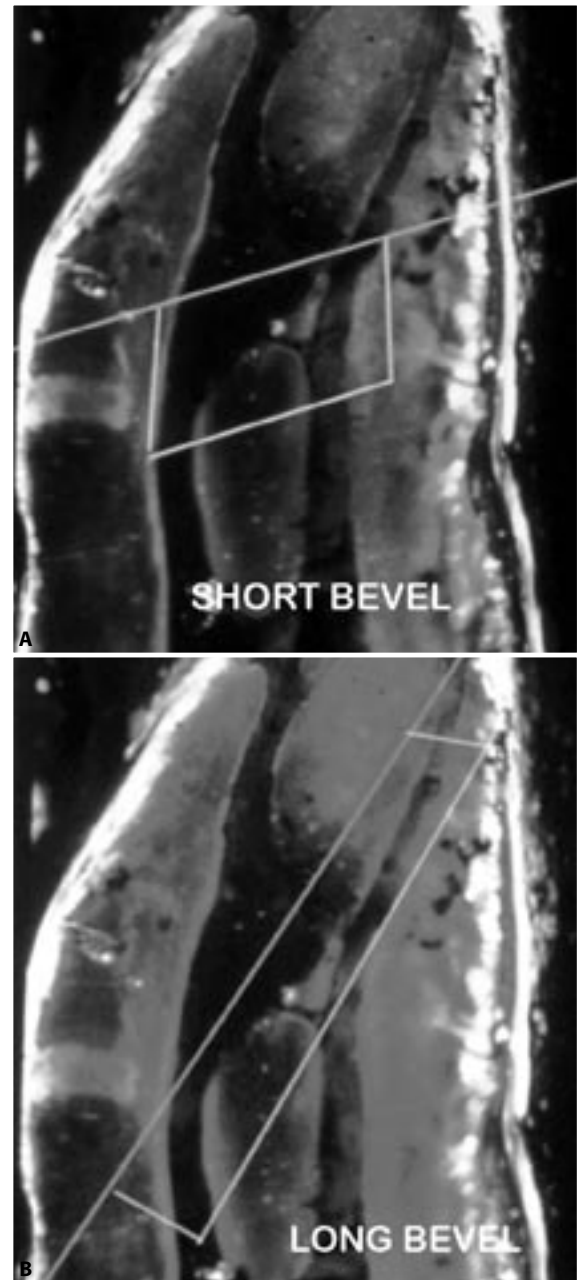


Fig. 34.58. **A.** The shorter bevel has less of a cavo-surface margin to contend with and is more predictably sealed as a result. **B.** When the cavo-surface margin dimensions are increased, the seal is not as predictable, simply because there is more margin to contend with (Courtesy of Dr. Gary Carr).

The root anatomy is especially important when there are more than two canals in one root. This occurs most commonly in maxillary bicusps and in the mesial roots of nearly all molars. However, the operator has to be constantly aware that multiple canals can occur in any root, no matter what tooth is being surgerized.

The refinement of the bevel is best accomplished with a #1171 carbide, surgical length, tapered fissure bur (Brassler) in an Impact Air 45 handpiece (Figs. 34.46, 34.47). This hand piece has no air exiting from the working end, which eliminates the possibility of an air emphysema or air embolism beneath the flap. *A standard high-speed handpiece should never be used for the above reason.* On occasion, the refinement of the bevel can cause additional bleeding. The operator should address this problem before proceeding any further. *Remember: 1) Sometimes it is necessary to go back a step, and 2) It is of the utmost importance to fully complete one step before proceeding to another!*

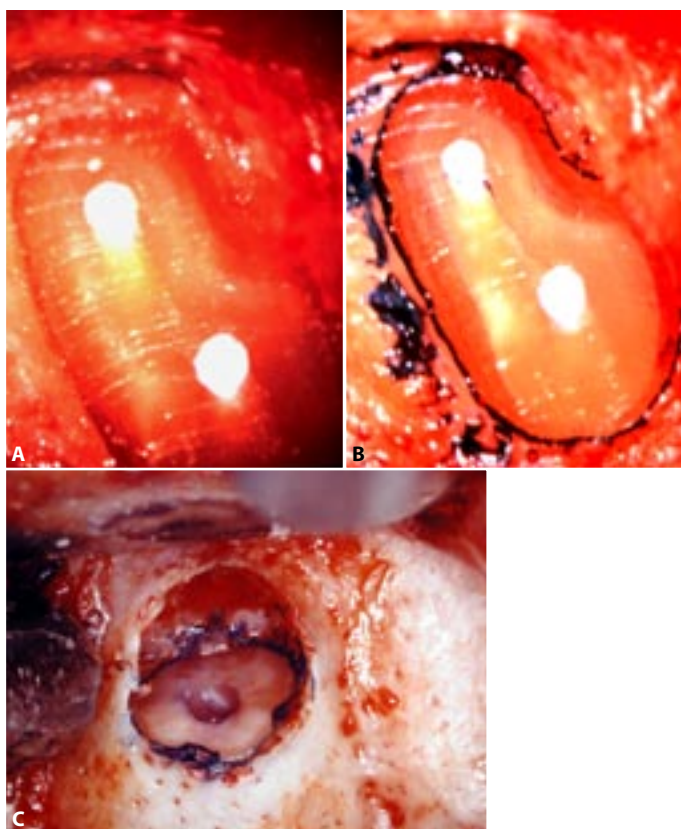


Fig. 34.59. **A.** It is difficult, and sometimes impossible to visualize anatomical variations on the unstained root surface. **B.** After staining with methylene blue, any anatomic variations, such as: isthmus tissue, accessory and/or missed canals, minute cracks, small fractures, periodontal ligaments, leaking fillings, etc. are much more evident (Courtesy of Dr. Gary Carr). **C.** Another example of a root surface after staining: the periodontal ligament is evident and the retro-prep is well centered (Courtesy of Dr. Arnaldo Castellucci).

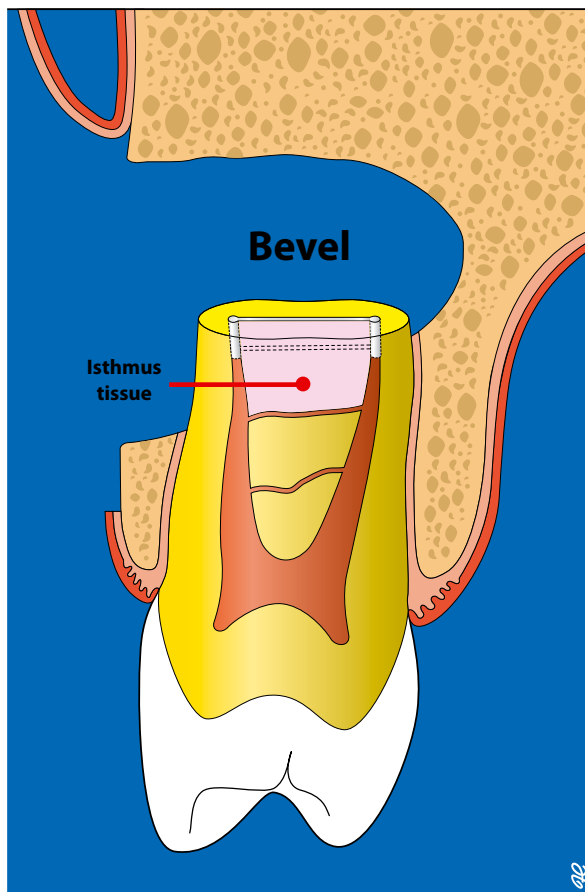
Methylene Blue Staining

After the bevel is refined and crypt management is completely under control, the apical surface is rinsed and dried with a Blue-Flo (Vista Dental), or Blue Max (Ultradent) plastic tip in a Stropko Irrigator (Vista Dental). Either one works well and will be referred to, from this point on, as a “blue plastic tip”. At first, the dried surface does not show any anatomical anomalies, and there may not be any present to be concerned about (Fig. 34.59 A). To be sure that all issues have been addressed, the dried surface is stained with 1% methylene blue (SybronEndo, Vista Dental) (Fig. 34.60). It is important to allow the methylene blue stain (MBS) on the tooth for a short period of time before gently flushing with sterile water. If there are any fractures, isthmus tissue, accessories, or any other anatomical variations present, the staining process will greatly enhance the operator’s ability to visualize them. Also, the MBS will display the periodontal ligament and so the operator can be sure the apex has been completely resected (Fig. 34.59 B, C). If after MBS, there is an accessory canal present, the easiest answer is usually to bevel past it and restrain to be sure the defect is completely eliminated. Or, if the occasion allows, the accessory can be “troughed out”, leaving the bevel as is.



Fig. 34.60. Unit dose Methylene Blue by Vista Dental, Racine, WI, USA.

When two canals are present in one root, it is necessary to prepare for an isthmus between the two canals even if the MBS didn't reveal one. It has been shown that in the mesiobuccal roots of the maxillary first molars with two canals, the 4mm section displayed a partial or complete isthmus 100% of the time.⁷¹ In studies of maxillary molars, two canals can be present as much as 93% of the time in the mesiobuccal root of the maxillary first molars, and 59% in maxillary second molars.⁶⁴ It is important to routinely prepare the isthmus, whether, or not, it is defined by staining; because post surgical remodeling of the beveled root surface may re-expose the canal system to bacterial invasion.⁶⁹ Although staining doesn't reveal the presence of an isthmus, it may lie just below the surface only to be exposed during the remodeling process. The rule is to always prepare an isthmus when there are two canals in one root (Fig. 34.61).



Ultrasonic Root End Preparation (REP)

With the advent of ultrasonics, and the array of tips available to the operator, it is now possible to prepare the root end adequately and to predictably accept several different root-end filling materials. The ultrasonic units vary as to performance and reliability. The piezo electric units (Amadent, EMS, Satelec-P5, and Spartan) are the most common and all have a good reputation for reliability and accept most tips on the market. Some older EMS units only accept tips made for its European thread, but the newer models accept all of the common tips manufactured in the United States.

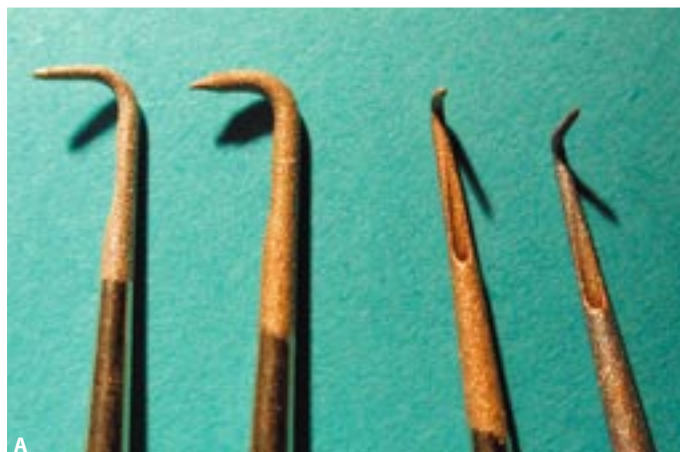
The basic requirements for a REP must include the following:⁷

- 1) The apical 3mm of the root end canal system must be cleaned and shaped.
- 2) The preparation is parallel to the anatomic outline of the pulpal space.
- 3) There is adequate retention form.
- 4) All isthmus tissue is removed.
- 5) The remaining dentinal walls are not weakened, or fractured.

The REP can be accomplished utilizing a multitude of different tips with various ultrasonic units. There are multitudes of ultrasonic tips to choose from that come in all shapes and sizes. The various ultrasonic tips can be divided into three groups: uncoated, chemically coated, and diamond coated. Clinically speaking, the cutting efficiency of an uncoated tip is not as great as the diamond coated tips, and the chemically coated tips (zirconium or titanium nitride), are somewhere in between. Some newer ultrasonic tips utilize port technology that delivers a constant stream

Fig. 34.61. Even though MBS may not show the presence of an isthmus, it may lie just below the surface and needs to be prepared for a predictable long term result

of water aimed directly to the working end of the tip (Fig. 34.62). They are very efficient and provide excellent vision for the operator during the REP. When using these tips, the operator must keep in mind that the water flow dampens the action of the tip and a higher power setting may be necessary to increase the cutting efficiency.



The most important consideration is not the brand of the unit, or type of tip, but how the instrument is used. The tendency for the new operator is to use the ultrasonic in the same manner (pressure and power-wise) as the hand piece and to begin with too much pressure and too high a power setting. The secret is an extremely light touch and at the lowest beginning power setting that is efficient for the tip in use. The lighter the touch, the more efficient the cutting and the lower power setting needed. Using the lowest efficient power setting will also extend the life of the tips. The correct amount of water is also important. If too much spray is used, visibility and cutting efficiency are both decreased. If too little is used, the necessary amount of cooling, or flushing of the debris will not occur. This can cause over heating of the cavo-surface, micro-cracks, and decreased vision may be the undesired result. Numerous studies have shown that when ultrasonics is used properly, micro cracks are not a normal occurrence and should not be a concern to the operator.^{4,39,47} It is therefore important to arrive at a balance between the amount of water coolant spray, power setting, and pressure used, as soon as possible in the beginning of the procedure.

Since the advent of ultrasonic techniques, the use of a rotary handpiece is no longer accepted as the standard of care for apical surgery.

The resultant use of ultrasonics for REP, instead of the conventional handpiece, has clearly demonstrated the ability to provide an anatomically correct REP, better sealing of the apical canal system, and fewer perforations.⁴⁰

Fig. 34.62. **A-C.** The coated ultrasonic tips, with water ports near the working tip, help prevent heat build-up and keep REP clean during preparation. The diamond coating on this KIS tip makes it a very efficient instrument for REP

It is important to have the correct tip available when needed while preparing the REP. The essential tips recommended to have on hand are:

- 1) anterior angled tips (90° and “back-action” 70°) (Fig. 34.63 A)
- 2) posterior angled tips (Fig. 34.63 B).

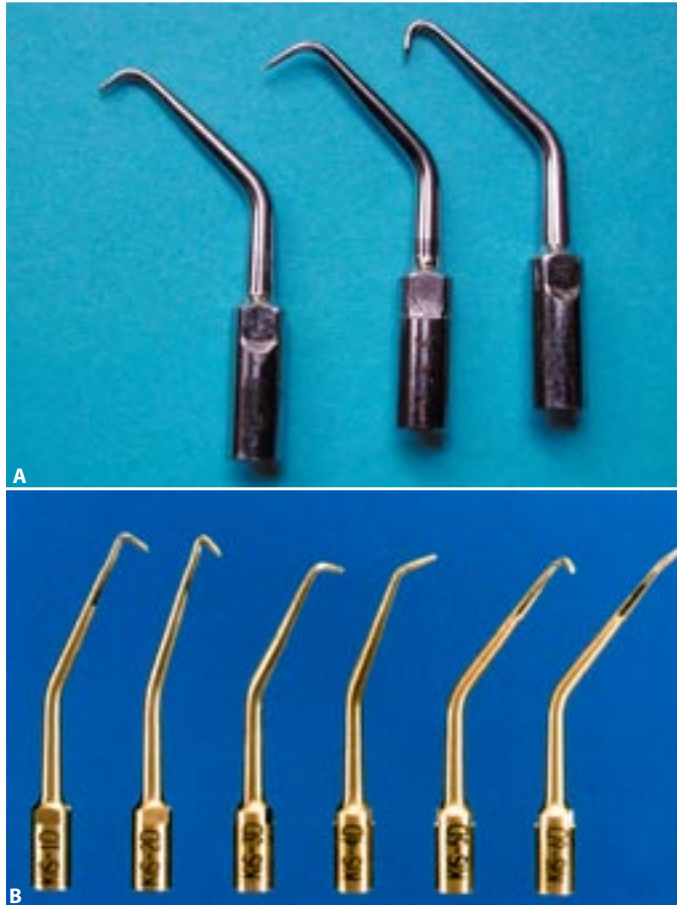


Fig. 34.63. **A.** Carr Tips angled at 90° and 70° (back action). **B.** Posterior angled tips (Kis Tips, Obtura Spartan).

It is also suggested that there be a variety of sizes and coatings available if needed. If the canal is large and/or filled with gutta-percha, a large, coarse, diamond coated tip can be used most efficiently. The various left and right tips are necessary on occasion, but in most cases, the anterior angled tips will suffice. The key is to slow down and be gentle, using a light, brushing movement.

For the preparation of an isthmus, a CTX explorer (SybronEndo) can be used to “scratch” a “tracking groove”. Then, with the water spray turned off, a very sharp pointed tip can be used to deepen the tra-

cking groove made by the explorer. This permits excellent vision, but the groove should only be deepened enough, without the water spray, to make a more definitive “tracking groove” for the tip to follow. The water spray should be resumed as soon as possible to allow for the cooling and cleaning of the tooth surface being prepared.

If difficulty is experienced when trying to establish a tracking groove, especially if the isthmus is very thin, the “Dot Technique” can be used. If the isthmus prep walls are too thin, it might be advisable to consider “going back a step” and do a little more beveling, then proceed to the REP. Staining the isthmus, prior to this step will greatly enhance the vision and accuracy of the preparation. With a sharp pointed tip inactivated and no water spray, place the tip exactly where desired on the isthmus, and then very quickly “tap” the rheostat for just an instant. Then repeat the process again, and again, as many times as necessary, until there are a series of “dots” created on the isthmus. Then it is a simple matter of connecting the dots to create the initial shallow “tracking groove” as described in the preceding paragraph (Fig. 34.64). In this manner, accuracy is completely controlled and the chance of “slipping off” a small, or thin, beveled surface is eliminated.

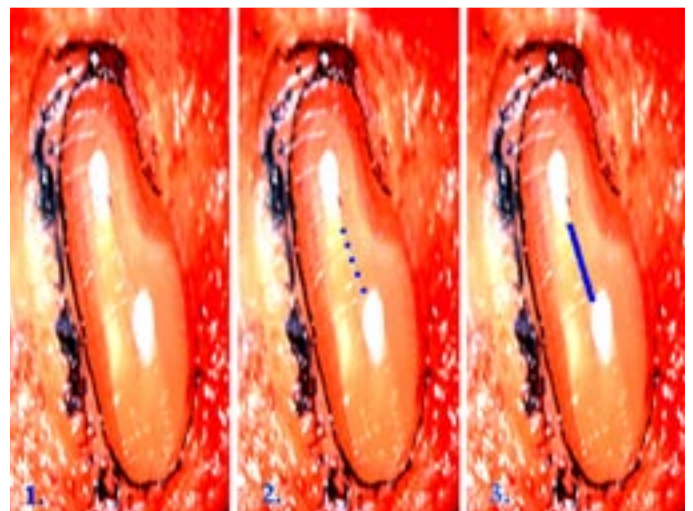


Fig. 34.64. **(1)** Whenever there are 2 canals in one root, the isthmus should always be prepared. **(2)** A simple way to accurately prepare the isthmus is to lightly place a sharp US tip where desired, with the water off, and “tap” the rheostat to activate it for just-a-second. **(3)** After several “dots” are placed, it is now a simple matter to connect the dots and create an initial “tracking groove” and prevent inadvertent “slipping-off” the desired isthmus track.

As soon as possible, after the groove is just deep enough to guide the tip, the water spray is turned back on. Then, while using a fine, pointed ultrasonic tip, the preparation is deepened to approximately 3mm. A larger tip can then be used to flatten out the floor of the root-end preparation (Fig. 34.65).

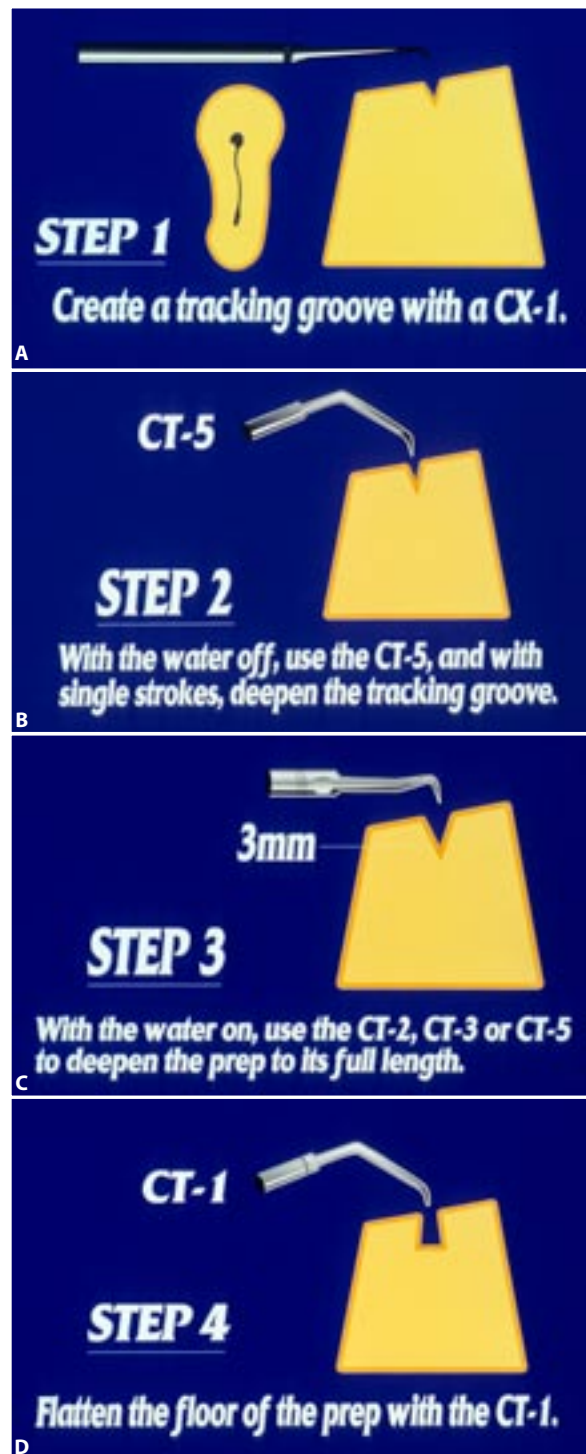


Fig. 34.65. **A-D.** Diagrammatic view of the four steps of the preparation of isthmus (Courtesy of Dr. Gary Carr).

Throughout the process, it's important to occasionally use the Stropko Irrigator to rinse and dry the root end preparation to remove debris. This facilitates inspection of the REP, which should be done at varying magnifications to be sure it is kept within the long axis of the canal (Fig. 34.66 A-C). The cleaning,



Fig. 34.66. Utilizing the Stropko Irrigator, a precise, controlled stream of water or air can be directed into the root-end preparation (REP) and effectively enhancing vision and the inspection process. **A.** A fine stream of water is used to flush out debris. **B.** A regulated stream air is used to dry the REP for better vision. **C.** The clean and dry REP is ready for inspection.

drying, and inspection of the REP is more efficient if the irrigating needle has been previously bent similar to the ultrasonic tip that is used for the REP (Fig. 34.17 A). A pre-cut and pre-bent 25 or 27gauge endodontic irrigating needle (Monoject) works well for this purpose. *Rinsing and thoroughly drying the REP is essential for good vision. After drying the REP, it is necessary to check the REP, at varying magnifications, for any remaining debris or unwanted material and to be sure the REP is extended properly to include “fins” and other anatomical aberrations that might be present (Fig. 34.67). Various sizes of micro-mirrors can be used to periodically inspect the preparation (Fig. 34.68). If an endoscope is available, many times the

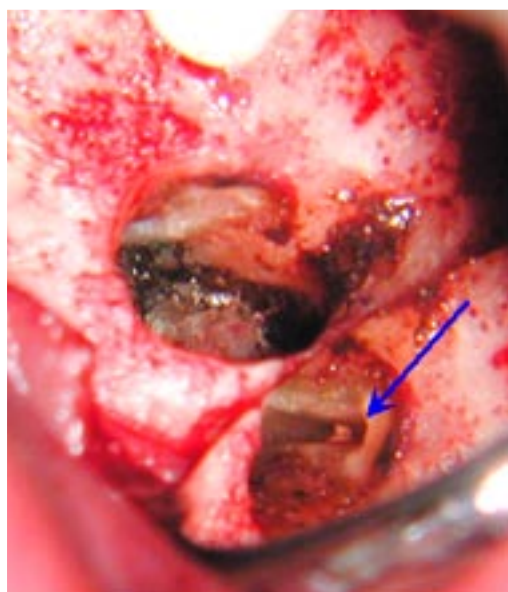


Fig. 34.67. The inspection of the clean and dry REP.



Fig. 34.68. EIE miniature retromirrors (Courtesy of Dr. Gary Carr).

interior of the REP can be easily viewed. Always keep in mind that cleanliness and dryness are essential for good visibility when using the SOM. The most common errors made during REP are:

Failure to resect completely through the root (Fig. 34.69).

The preparation is not within the long axis of the root (Fig. 34.70).



Fig. 34.69. The retrofill has been positioned without resecting completely through the root: the apical delta remained untouched, leaving three portals of exit unsealed (Courtesy of Dr. John West).



Fig. 34.70. The preparation is not within the long axis of the root (Courtesy of Dr. Gary Carr).

The isthmus has not been adequately prepared (Fig. 34.71).

Incomplete buccal or lingual extensions to the preparation (Fig. 34.72).

Failure to recognize and deal with anatomical variations or complexities (Fig. 34.73).

Failure to inspect and remove all debris from the preparation.

Of particular interest is the buccal aspect of the internal wall of the prep. Often this area is not cleared of all debris due to the angulation of the instrument within the canal system (Fig. 34.74). If there is so-

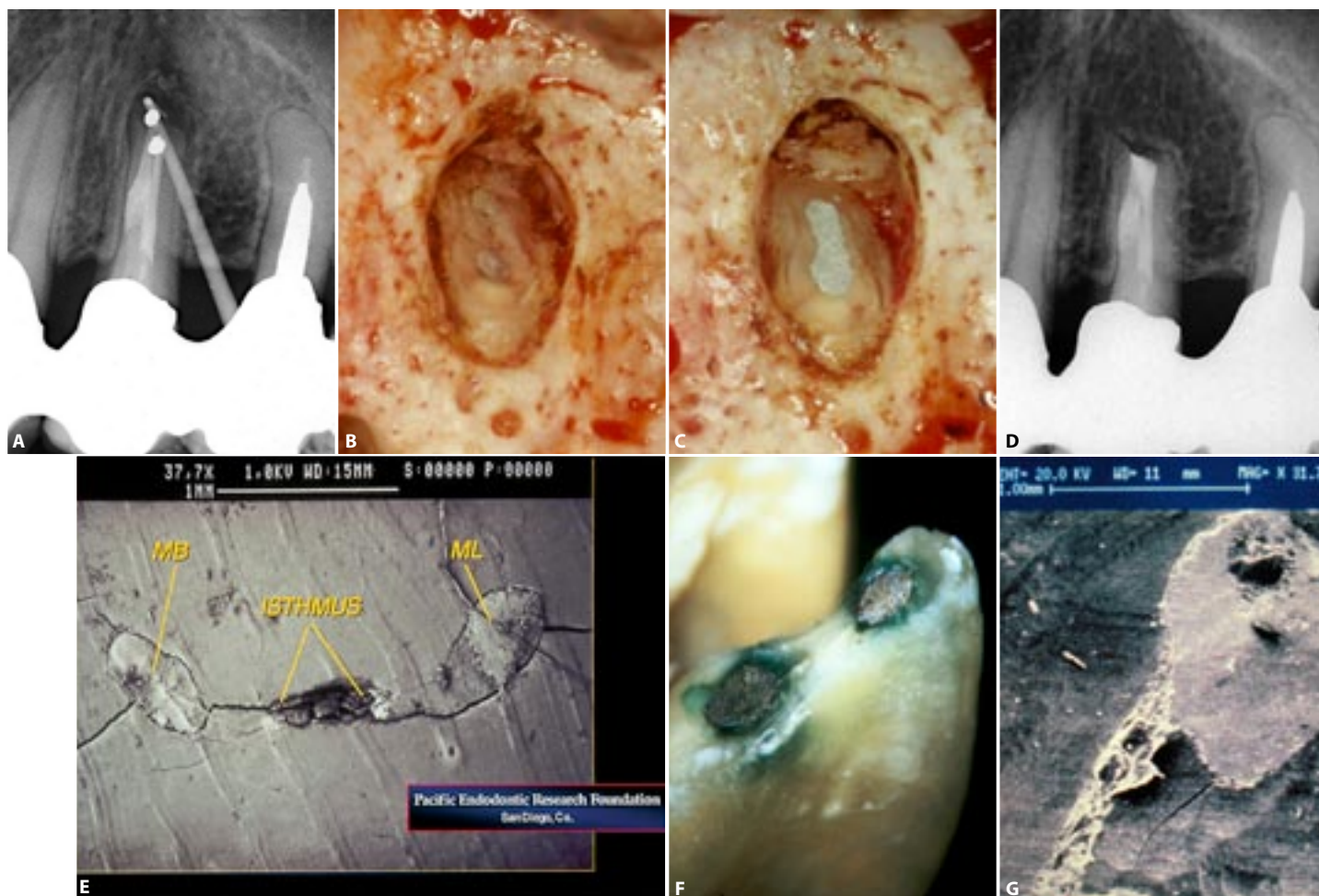


Fig. 34.71. **A.** The preoperative radiograph shows a failing retrofill in an upper first premolar. **B.** The two canals had been obturated separately and the isthmus had been missed. **C.** The isthmus has been adequately prepared and sealed. **D.** Two year recall (Courtesy of Dr. Arnaldo Castellucci). **E-G.** More examples of missed isthmuses (Courtesy of Dr. Gary Carr).

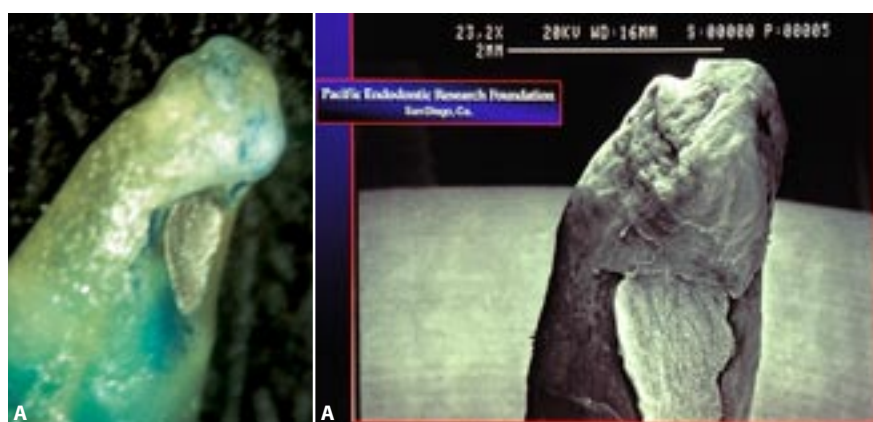


Fig. 34.72. **A, B.** The preparation has not been extended completely in a buccal to lingual direction (Courtesy of Dr. Gary Carr).

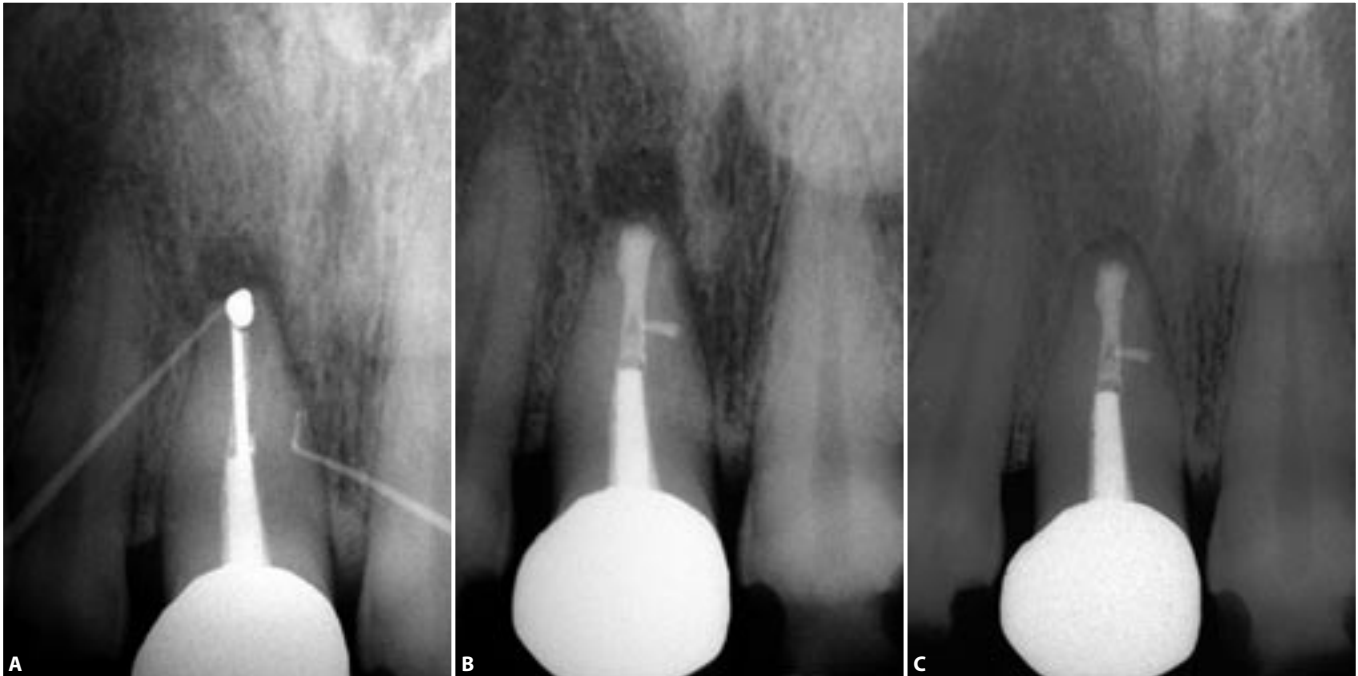


Fig. 34.73. **A.** The upper right central incisor has two fistulous tracks, one from the apical lesion and the other from the lateral lesion. Due to the crown and the post, the surgical procedure is indicated. **B.** Postoperative radiograph. Both the root apex and the lateral canal have been filled. **C.** Two year recall (Courtesy of Dr. Arnaldo Castellucci).



Fig. 34.74. During the inspection process, one of the most common observations is gutta percha remaining on the buccal wall of prep (Courtesy of Dr Gary Carr).

me gutta-percha “streaming up” the side of the wall, and the REP is finished, the best thing is to take a small plugger and fold the gutta-percha coronally so the wall is clean once more. It is usually futile to try to remove those small bits of gutta-percha with an ultrasonic tip.

After completion of the REP, the preparation should be rinsed and dried with the Stropko Irrigator and inspected to be sure it is clean, within the long axis of the canal system, and properly extended. The use of micro-mirrors and varying powers of magnification

will enable the operator to verify the REP is completed. At this time, the REP is etched with a 37% phosphoric acid gel (Ultradent) to remove the smear layer if desired. After 20 seconds, the REP is again thoroughly rinsed, dried and re-examined under varying powers of the SOM. If all is as desired, the root end preparation is complete and ready to be filled.

Use of antimicrobials, such as chlorhexidine, in the surgical crypt is debatable. Possible adverse effects on bonding REF materials and retardation of the healing process may be considerations in its use.

Section 5: Root End Filling (REF)

Root End Filling Materials

The operator is now at a stage in the microsurgical procedure where the tissues have been atraumatically retracted, the crypt is well managed and the REP is ready to fill. Ideally, the materials used for the REF should meet the following requirements:⁸

1. Provide for easy manipulation and placement with adequate working time.
2. Have dimensional stability after being inserted.
3. Be able to hermetically seal the root end preparation and the entire resected root surface (if desired). *The author prefers to only seal the REP, leaving the resected root surface exposed.*
4. Conform and adapt easily to the various shapes and contours of the REP.
5. Be biocompatible and promote cementogenesis.
6. Be nonporous and impervious to all periapical tissues and fluids.
7. Be insoluble in tissue fluids, not corrode or oxidize.
8. Be non-resorbable.
9. Be unaffected by moisture.
10. Be bacteriostatic, or not encourage bacterial growth.
11. Be radiopaque, or easily discernable on radiographs.
12. Not discolor tooth structure of the surrounding tissues.
13. Be sterile, or easily and quickly sterilizable immediately before insertion.
14. Be easily removed if necessary.
15. Be non carcinogenic, and nonirritating to the periapical tissues.

There are several materials that are currently available for REF: amalgam, IRM, Super EBA (SEBA), Optibond, Gerestore, and more recently, Mineral Trioxide Aggregate (MTA). Research can be found supporting any of the above materials and success has been claimed for them. The author doesn't want to recommend or condemn any REF material (except amalgam), but will generalize and relate his, and other's experiences with them and opinions about their applications.

Amalgam and IRM were used for many years as the only commonly available REF materials. However, in almost every "leakage" study published during the past few years, amalgam has proven to be the worst

offender, consistently exhibiting the greatest amount of leakage.¹ These observations, accompanied by the general controversy over the presence of mercury in amalgam, strongly suggest that there is no valid reason to continue its use as REF material. The only real advantage to amalgam is the favorable radiopacity (Fig. 34.75).

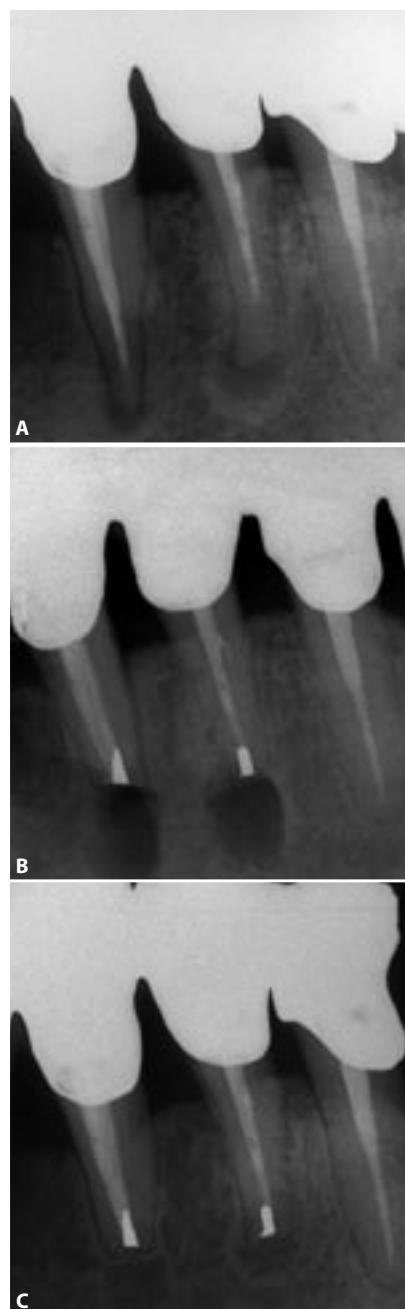


Fig. 34.75. Of all root-end filling materials, amalgam displays the best radiopacity. **A.** Pre-op radiograph of patient referred for surgical endodontics. **B.** Postoperative radiograph. **C.** Two year recall (Courtesy of Dr. Arnaldo Castellucci).

Super EBA

Since the advent of the anatomically correct, ultrasonic REP, Super EBA (SEBA) has become an accepted and widely used REF material (Fig. 34.76). Drs. Carr,



Fig. 34.76. The SuperEBA has been used for many years as a root end filling material.

Rubinstein, Ruddle and Castellucci popularized SEBA in their many lectures over the past several years. A recent study demonstrated a success rate of approximately 91.5% using SEBA.⁵⁷ The author used SEBA routinely from 1992 to 1996 with favorable results and full confidence of its sealing capabilities.

The major drawback of SEBA is its technique sensitivity. The surgical assistant had to mix the SEBA until it was a thick, dough-like consistency, and roll it into a thin tapered point. The “dough-like” tapered end of the thin SEBA “roll” was segmented and handed to the doctor on the end of either a small Hollenbeck, or spoon (Fig. 34.77), and subsequently inserted into the

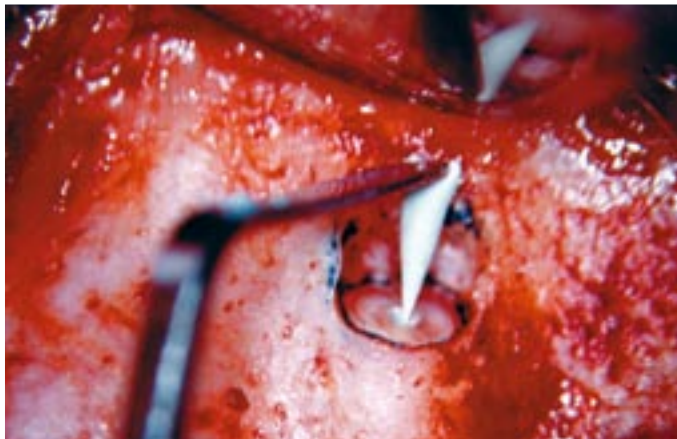


Fig. 34.77. The tapered end of the SuperEBA roll is being positioned inside the retroprep (Courtesy of Dr. Arnaldo Castellucci).

REP, then gently compacted coronally with the appropriate plugger. For even a well-trained assistant, this was often the most stressful part of the microsurgical procedure. Two to five of these small segments were usually necessary to slightly overfill the REP. Another problem experienced by many, was that SEBA was unpredictable as to its setting time: sometimes setting too quickly, and at other times, taking much too long for the tired surgeon. The ambient temperature and humidity had a profound effect on the setting time. Cooling the glass slab used to mix the SEBA could extend setting time. At any rate, after the REF was complete, an instrument and/or a multi-fluted finishing bur were used to smooth the resected surface, producing the final finish (Fig. 34.78). A mild etchant was

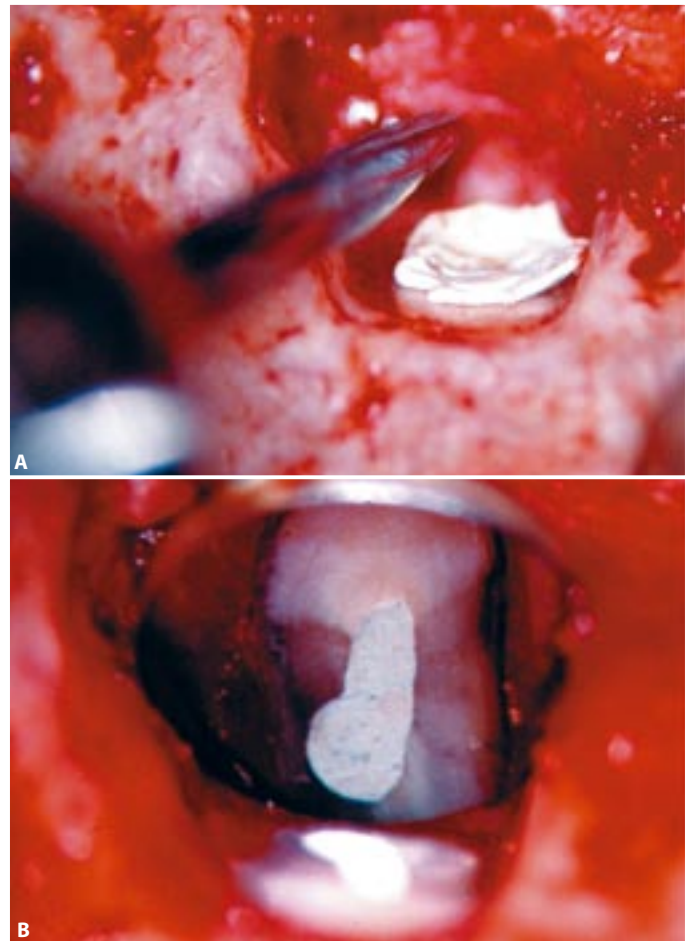


Fig. 34.78. Once the material is completely set (A), the excess is removed and the retrofill is finished (B). (Courtesy of Dr. Arnaldo Castellucci).

then used to remove the “smear layer” that was created during the final finishing process (Fig. 34.79).



Fig. 34.79. Typical post operative, clinical appearance of SEBA root-end filling material in the buccal root-ends of a maxillary first molar (Courtesy Dr. Yosef Nahmias).

The removal of the “smear layer” and the demineralization of the resected root end are thought to enhance cementogenesis, the key to dentoalveolar healing, by exposing the collagen fibrils of the dentin and cementum.¹⁴ One of the earlier disadvantages of SEBA was a radiopacity comparable to that of gutta-percha, so it was necessary to educate the new referring doctor that a REF had indeed been performed (Fig. 34.80). Today, this is not an issue because the profession is not as “fixated” on radiopacity as in the past. Most new materials (composites, MTA, glass ionomers, etc.) have a similar radiopacity to that of SEBA and gutta-percha.

Bonding

Bonding, using composite REF materials, is now possible due to the ability to have total control over the apical environment (crypt management). It is essential that the crypt management process is uncompromised if successful bonding techniques are desired. Even a small amount of contamination can cause a failure of the bond to the dentin surface and result in micro-leakage.⁴⁵ Theoretically, any dual cure composite can be used as a REF material.

Gerestore (Den-Mat, USA), a glass ionomer composite, is popular to use as a REF because of its ease of use and good clinical properties. It has good flow ability,

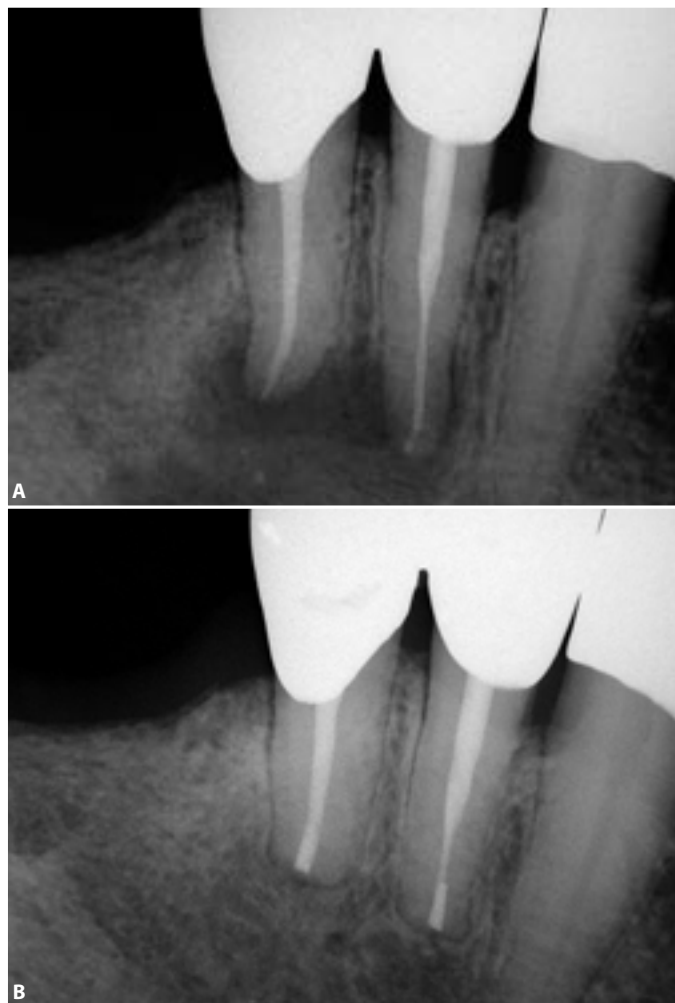


Fig. 34.80. **A.** Pre operative radiograph. **B.** Two year recall. The radiograph shows the radiopacity of a SEBA REF is similar to gutta percha. (Courtesy of Dr. Arnaldo Castellucci).

and demonstrates biocompatibility to the surrounding tissues.⁶¹

Optibond (SybronEndo, USA) is also a very popular composite for bonding in the REF. It has excellent flow ability, easily placed with a Carr explorer, adequate working time, and is dual-cure. The following series of pictures demonstrate a typical Optibond REF in a maxillary first bicuspid shows how the insertion of the selected material, and curing by light is accomplished in a routine manner when bonding into the REF (Fig. 34.81). **Note:** Since the light source for the SOM is so intense, the light source on the microscope should be minimized as much as possible while placing a light cure or dual cure composite to prevent a significant decrease in setting time. Orange filters are readily available to replace the “blood filter” on most SOM light sources. Using these orange filters, gives

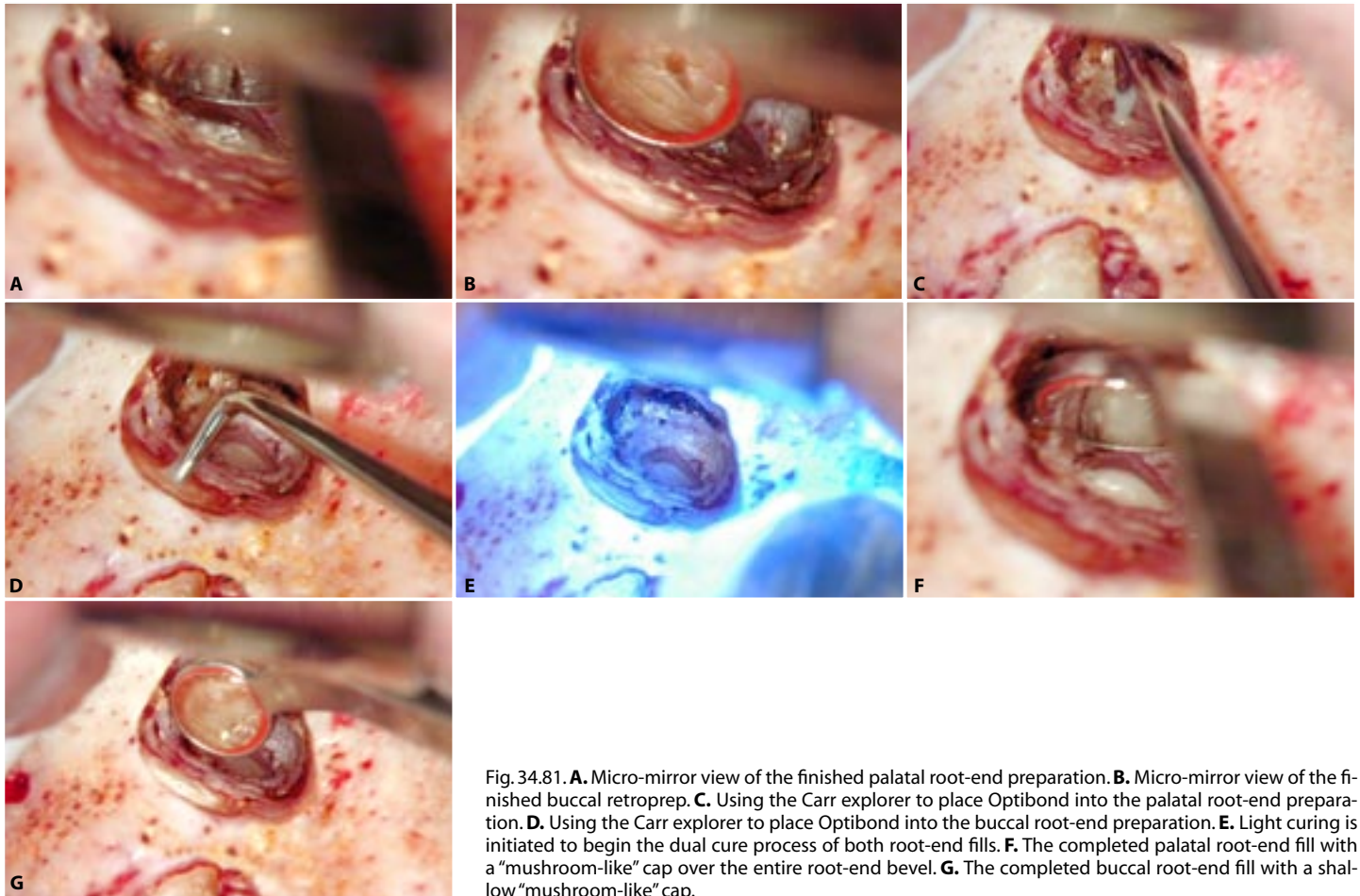


Fig. 34.81. **A.** Micro-mirror view of the finished palatal root-end preparation. **B.** Micro-mirror view of the finished buccal retroprep. **C.** Using the Carr explorer to place Optibond into the palatal root-end preparation. **D.** Using the Carr explorer to place Optibond into the buccal root-end preparation. **E.** Light curing is initiated to begin the dual cure process of both root-end fills. **F.** The completed palatal root-end fill with a "mushroom-like" cap over the entire root-end level. **G.** The completed buccal root-end fill with a shallow "mushroom-like" cap.

the necessary working time when placing light cured, or dual cured materials (Fig. 34.82). For most microscopes, an orange filter is available that easily and inexpensively replaces the "blood filter" on the SOM. After the composite is completely cured, the "mushroom-like" cap can be left alone and the REF is complete. Or, if desired, the REF can be finished with a high speed finishing bur and the resected root end etched with 35% phosphoric acid gel (Ultradent) for about 15-20 seconds, to remove the "smear layer" and to demineralize the surface.

Studies have shown a good long-term healing with resin bonding techniques and many operators used it as their technique of choice.⁵⁸ It is imperative that good hemostasis is achieved so the bonding process is not contaminated with moisture. One of the disadvantages of some composite resins is their poor radiopacity, necessitating education of the patient and/or referral source.

However, there is controversy as to whether the resected surface of the root should also be coated with the bonding material.²³ A "cap", or "dome", of mate-

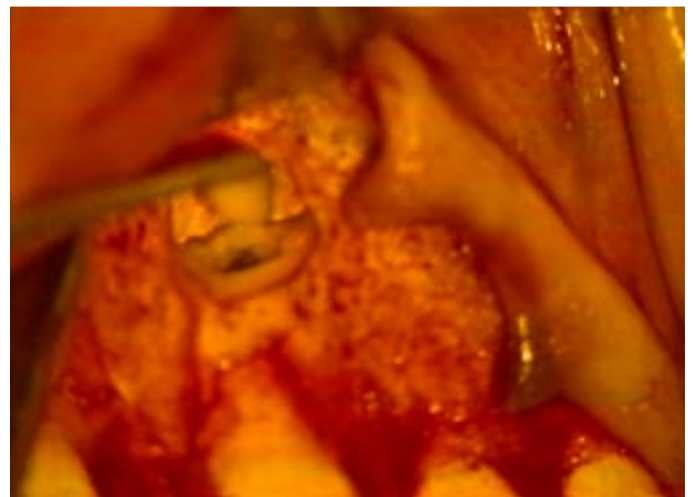


Fig. 34.82. Using an orange filter before placing either a light cured or dual cured composite gives the operator the working time necessary to place the material.

rial is placed (usually Gerestore or Optibond) over the entire resected root surface with the intention of sealing all of the exposed tubules.³² The operators cove-

ring the resected surface believe it is necessary to ensure a good seal and the predictability would be better. On the other hand, there is also the opinion that the exposed tubules are not a factor concerning the predictability of the healing process. In fact, it is believed that nothing would heal as well, or was more biocompatible than the clean, exposed dentin of the apically resected surface.¹⁴ The author does not worry about whether the exposed apical surface is covered or not, and is convinced the jury is still out on this issue! Clinical observation indicates that if all steps are done properly, the surgery will be successful if the REF is “mushroomed”, or not.

Mineral Trioxide Aggregate (MTA)

More recently, MTA (Dentsply Intl) has become very popular and is widely used as a retrofill material (Fig. 34.83 A, B). There are many publications extolling the virtues of this material regarding its sealing capabilities and its biocompatibility with the surround-

ing tissues.^{1,40,67} MTA has been shown to have superior sealing qualities to either SEBA or amalgam.⁷² The cellular response to MTA is also proven to be better than IRM and does stimulate interleukin production indicating biocompatibility with adjacent cells.^{34,48}

The main advantage of MTA is the forgiving handling qualities. The material is easily placed with one of the various MTA carriers. Some available carriers used to place MTA into the REP include the Retrofill Amalgam Carrier (Miltex, York, PA, USA), the Messing Root Canal Gun (Miltex, York, PA, USA), Dovgan MTA Carriers (Quality Aspirators, Duncanville, TX, USA) (Fig. 34.84 A, B), the MAP System (Produits Dentaires, Vevey, Switzerland) (Fig. 34.85), the Lee MTA Pellet Forming Block (G. Hartzell & Son, Concord, CA, USA) (Fig. 34.86) and other types (Fig. 34.87).

The Lee MTA Pellet Forming Block is a very simple and efficient device for preparing MTA to be carried to the REP.^{36,37} Properly mixed MTA is simply wiped on to a specially grooved block and the Lee Instrument is



Fig. 34.83. MTA is marketed as **ProRoot** and is available in one gram (1Gm) packages, from Tulsa Dental, Dentsply International. **A.** White MTA. **B.** Grey MTA



Fig. 34.84. **A.** The three Dovgan MTA Carriers have different diameters. The smallest size is best used for perforation repairs. *They must be cleaned immediately after use to prevent clogging.* **B.** The three Dovgan MTA Carriers produced by Quality Aspirators (Duncanville, Texas).

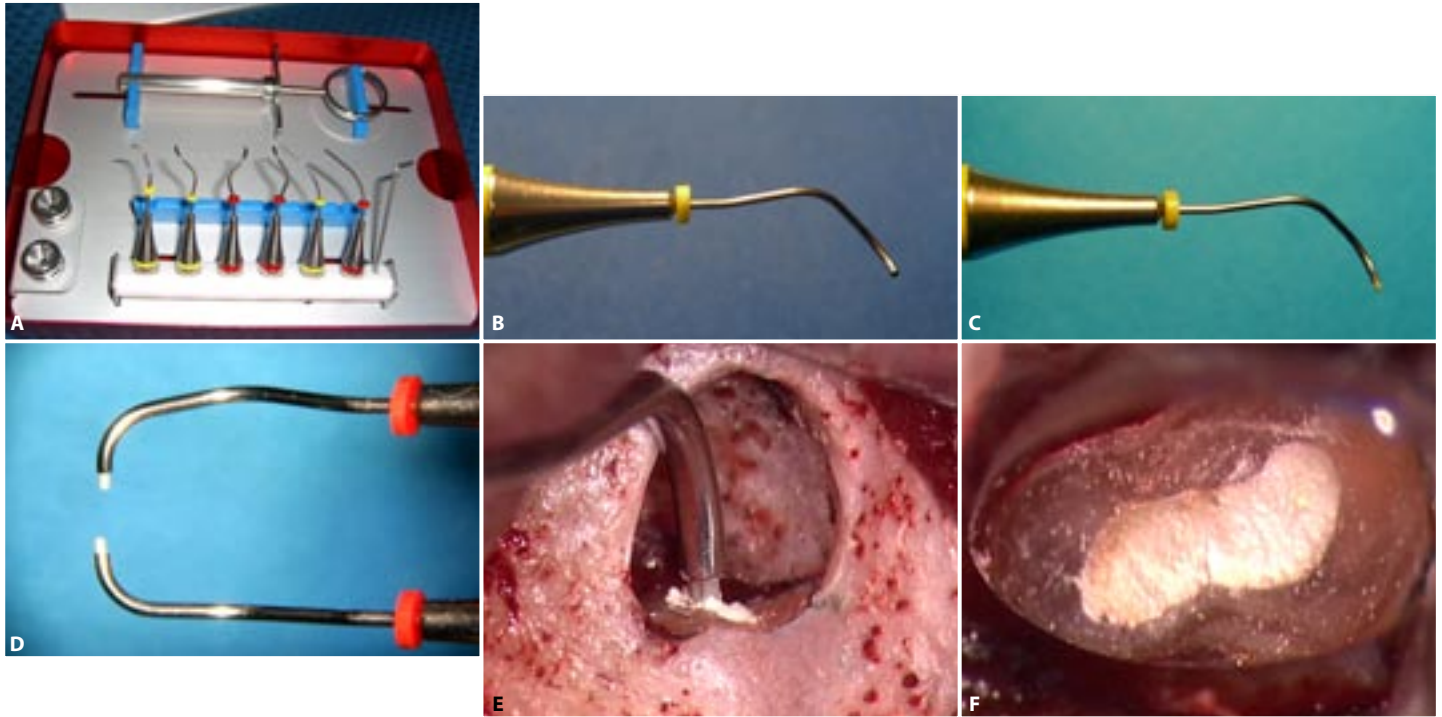


Fig. 34.85. **A.** The Micro Apical Placement (MAP) System. **B, C.** The piston is in silicone to better slide inside the curved needle. **D.** Thanks to the triple curvature of the needle, the placement of MTA is facilitate in posterior teeth. **E.** The MAP System is carrying the MTA in the retroprep. **F.** The retrofill has been completed and finished. (Courtesy of Dr. Arnaldo Castellucci).

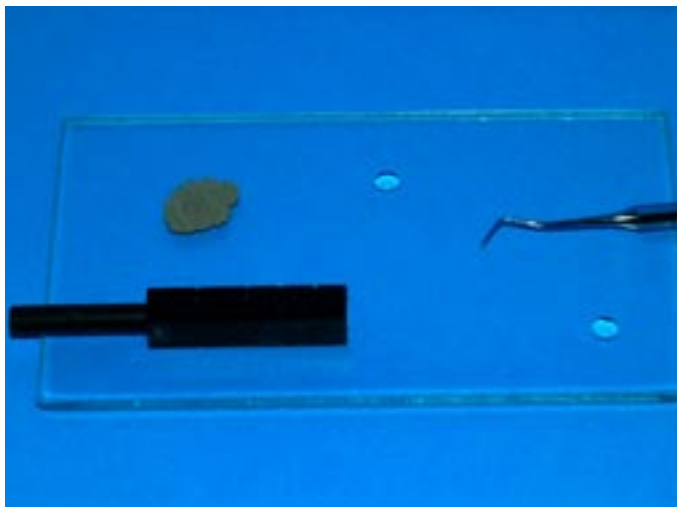


Fig. 34.86. The MTA carrier designed by Edward Lee.



Fig. 34.87. There are several other designs of MTA carriers available on today's market. Pictured are some of the different styles to choose from.

used to slide the desired length of MTA out of the one of the appropriately sized grooves (Fig. 34.88). The MTA adheres to the tip of the instrument allowing for easy placement into the REP. Using this method of delivery is really efficient and fewer “passes” are required to adequately fill the REP (Fig. 34.89). As with any other MTA carrier, use of the Lee Pellet Forming Block

requires the correct powder/water ratio of MTA for ease of use. It is imperative that the mix be wet enough not to crumble, but dry enough to prevent “slumping”. Adding or removing water from the mixture easily obtains the desired “working consistency”.

Using the appropriate carrier, the MTA is extruded in a pellet form and “patted” or “tamped” to place

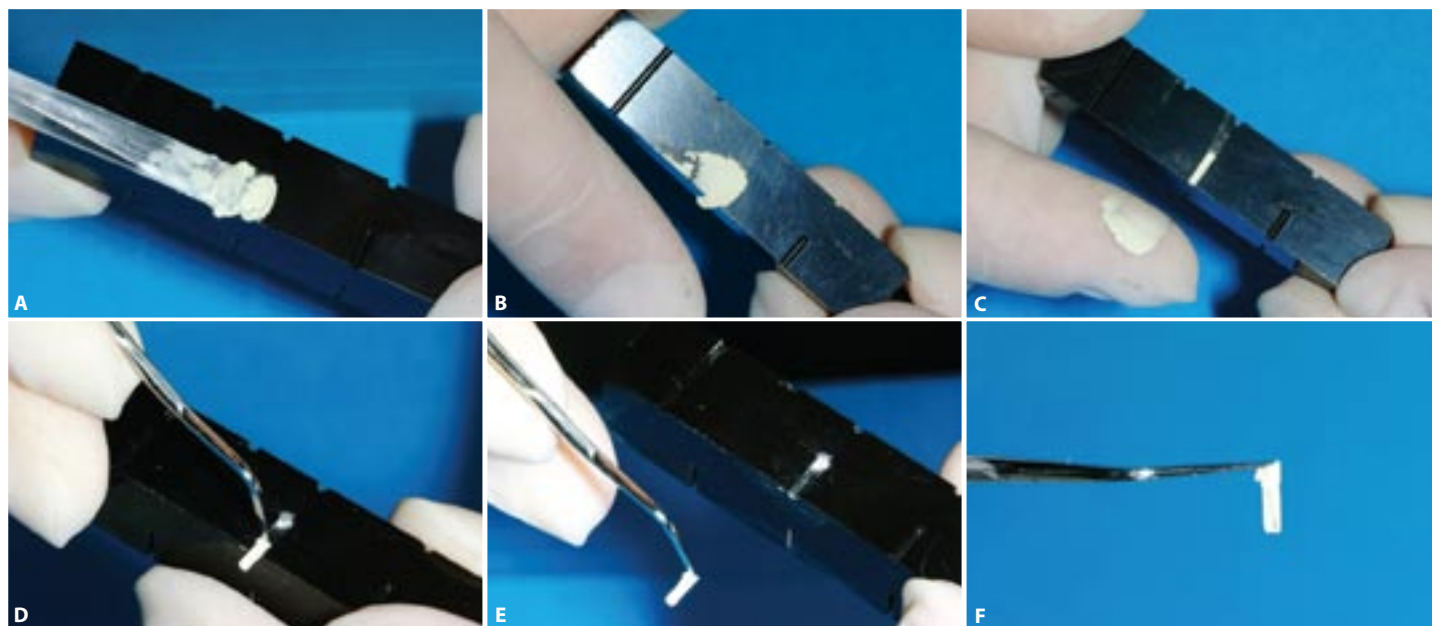


Fig. 34.88. The Lee MTA Pellet Forming Block greatly simplifies the process of delivering MTA to the root-end preparation (REP). **A.** The MTA is mixed to a ‘putty-like’ consistency, placed on the end of a spatula, then placed into the appropriate size groove in the Lee MTA Block and (**B, C**) pressed into the groove with a finger, (**D**) the desired length of the MTA is selected, (**E**) and is removed by the instrument, then (**F**) carried to the REP in an efficient manner. (Courtesy of Dr. Arnaldo Castellucci).

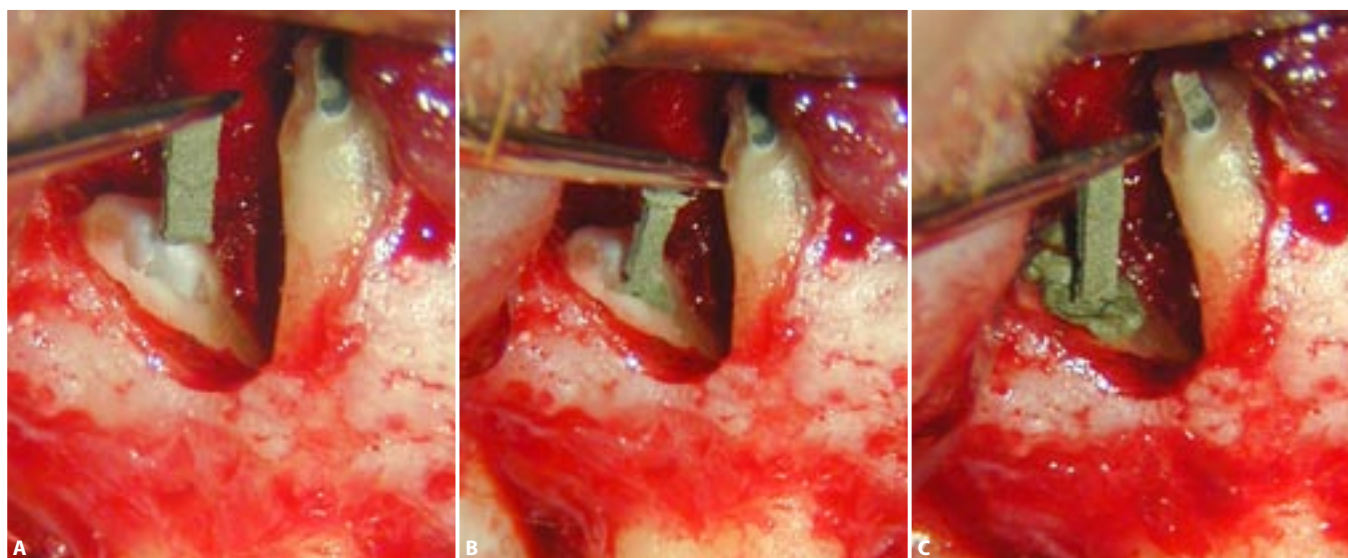


Fig. 34.89. **A.** The pre-measured aliquot of mineral trioxide aggregate (MTA) is easily delivered into the root-end preparation (REP). **B.** A sufficient quantity of MTA can be carried on the instrument to minimize the number of ‘passes’ the surgeon has to make. **C.** Because of the efficiency of this system, in most cases, only two to three aliquots will suffice to slightly overfill the REP with MTA.

with an appropriate plugger-type instrument. These MTA carriers have greatly reduced the frustration of placing MTA accurately and easily into the REP. Their various sizes enable the operator to place the MTA into the REP. For example, the smaller .8 mm tip fits into the average REP so the MTA can be expressed to the floor of the preparation to insure excellent placement.

Condensation, as we normally perceive it in dentistry, should be avoided while placing this material. The secret to using MTA is to keep it dry enough so it doesn't flow too readily (like wet sand), but yet moist enough to permit manipulation, maintain adequate "hydration", and a workable consistency. The desired "working consistency" is easily accomplished by using a cotton pellet (dry or moistened with sterile water) or a Stropko Irrigator (Vista Dental, Racine, WI, USA) using air or water, depending on whether it is necessary to add or subtract water from the surface of the MTA mixture.

If the assistant touches the plugger with an ultrasonic tip during the placement process, flow is enhanced, entrapped air is released, and the density of the fill is improved (Fig. 34.90). Doing this "densification" procedure also increases the radiodensity (radiopacity) of the MTA in the post-op radiograph, but it is still similar to gutta-percha (Fig. 34.91).

MTA has a working time of approximately two hours, which is more than adequate for apical microsurgery and takes much "time pressure" out of the surgical procedure. Finishing the MTA is simply a matter of carving away the excess material to the level of the

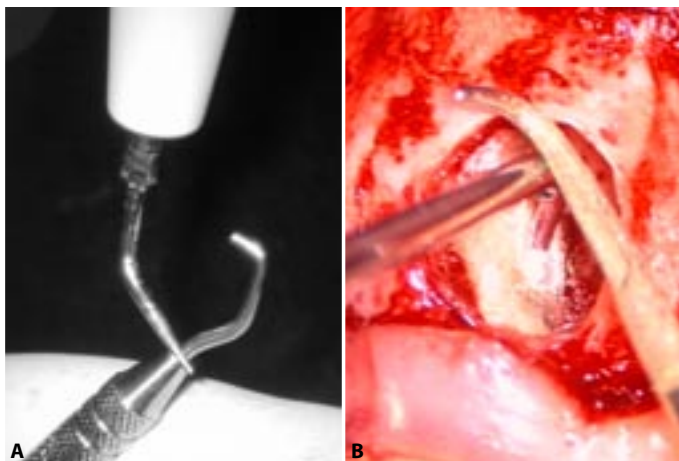


Fig. 34.90. **A, B.** To "densify" the MTA already placed into the root-end preparation (REP), bubbles of air and excess water can readily be removed. The surgical assistant lightly touches the ultrasonic tip to the non-working end of the instrument in contact with the MTA. This "densification" process enhances the "workability" and the radiopacity of the MTA root-end fill (REF).

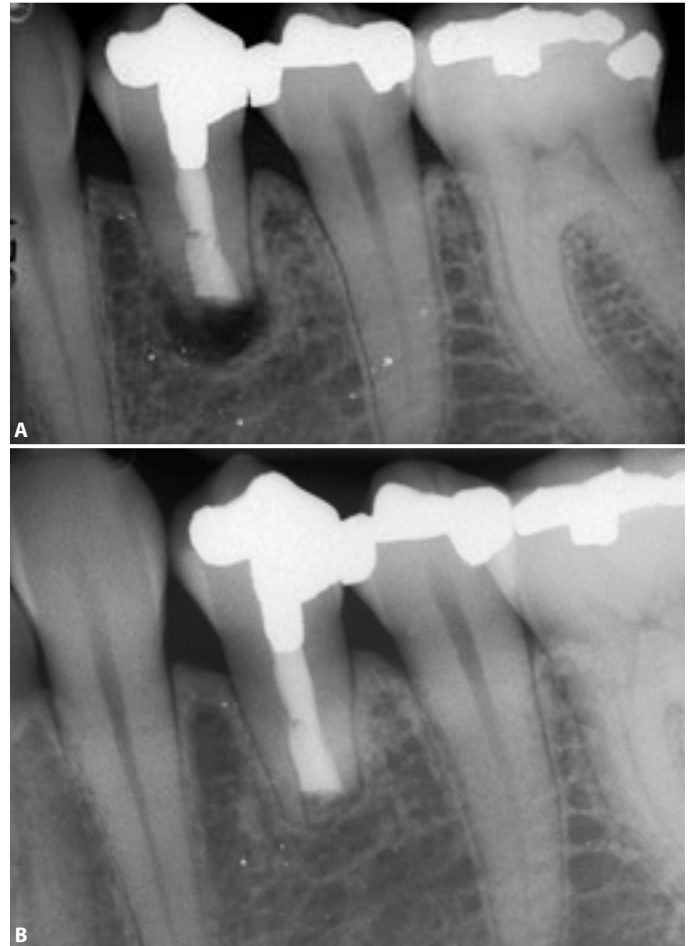


Fig. 34.91. After "densification," the radiopacity of the MTA root-end fill (REF) is slightly enhanced. **A.** Postoperative radiograph: the retrofill has been made using MTA. **B.** Three year recall (Courtesy of Dr. Arnaldo Castellucci).

resected root end. The moisture necessary for the final set is derived from the blood, which fills the crypt after surgery. The MTA is hydrophilic and depends on moisture for the final set, so it is imperative that there is enough bleeding re-established after crypt management to ensure the crypt is filled with blood, unless Calcium Sulfate is to be used for GBR. The filling of the crypt with either blood, or a GBR material, can be considered the final step in "crypt management". This is especially true when MTA is used as the REF material.

Based on current studies the operator can choose any one of the above mentioned REF materials and be comfortable that if the proper protocol is followed, the apical seal will be predictable and healing uneventful.

Optional Microsurgical Procedures

Trans-Sinus Apical Surgery

Apical surgery on the palatal roots of maxillary molars has traditionally been performed by laying a relatively large palatal flap (Figs. 34.92, 34.93). This very thick soft tissue was difficult to manage;

the surgical flap was large by necessity, and the patient's post-operative discomfort usually measurable. Added to this, the surgeon's vision was severely compromised and the proximity to potentially problematic anatomical landmarks was always a concern (the greater palatine and naso-palatine arteries and nerves, for example) (Fig. 34.94).



Fig. 34.92. **A, B.** Sulcular palatal flap to perform periapical surgery on the palatal root of a maxillary first molar. **C.** The flap is being raised. **D.** View of the amalgam retrofill. **E.** Suture (Courtesy of Dr. Arnaldo Castellucci).

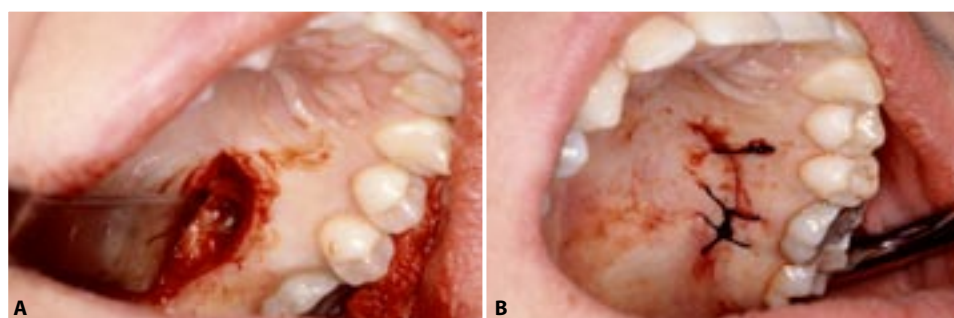


Fig. 34.93. **A.** Semilunar palatal flap to perform periapical surgery on the palatal root of a maxillary first molar. **B.** Suture (Courtesy of Dr. Melvin Harris, Boston, Mass.).



Fig. 34.94. The greater palatine foramen.

Since the advent of the SOM and the Endoscope (ES), new surgical techniques, concepts and instruments have been developed. The “Trans-sinus Approach” to the palatal root has been a more favorable option. The vision is far better and the access easier than using the palatal approach. This, along with less discomfort from the patient and more uneventful healing, has increased the acceptance and popularity of the technique. Clinical observations confirm that the Snyderian membrane of the sinus has as great a potential for healing as that of the periodontal ligament. Not too long ago, entry into the sinus was thought to be a major event. In today’s world, entry into the sinus is a non-event and even antibiotics aren’t routinely prescribed.

There are limitations to non-surgical endodontic treatment and not all problems can be successfully eradicated. One of the most significant is the presence of a periapical biofilm containing microorganisms that are resistant to antibiotics and can only be treated surgically (Fig. 34.95). The main concern is to prevent any foreign objects, or medicaments, from entering the sinus cavity. *This is described later in this section.*

The presurgical examination should include at least three different radiographic angles to better ascertain the palatal inclination of the palatal root in relation to

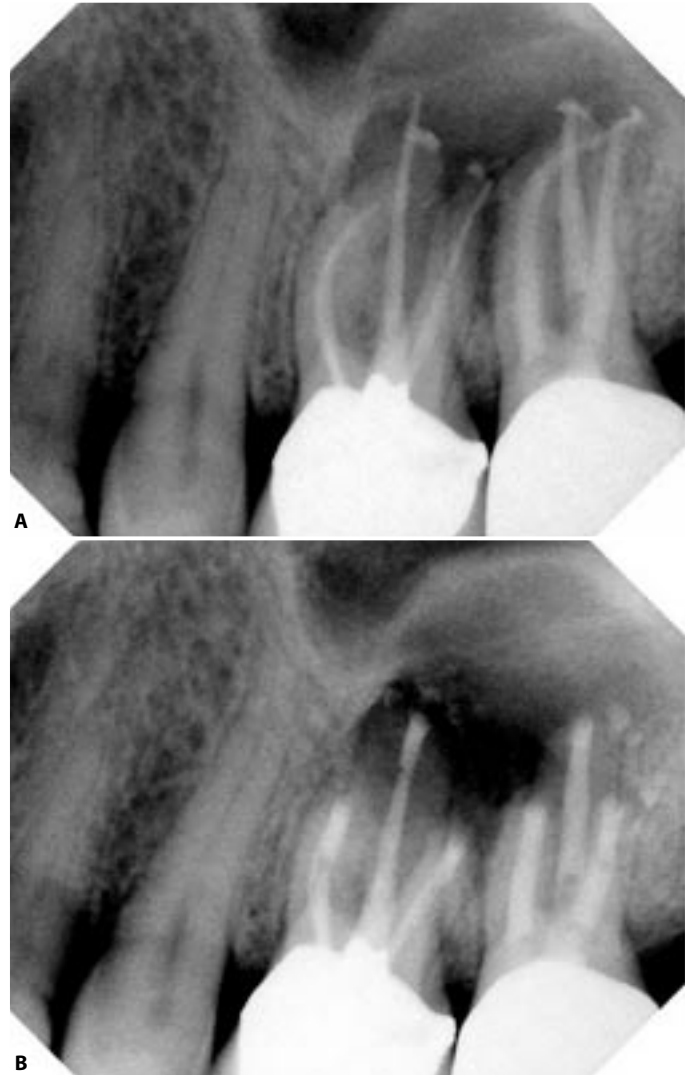


Fig. 34.95. **A.** The pre-op radiograph of the first and second molars to have apical microsurgery due to an unfavorable response to non-surgical endodontic treatment. **B.** Post-op Radiograph resulting from apical microsurgery shows the extent of access necessary to adequately treat the palatal roots does not have to be excessive.

the buccal roots. If there is a wide variation to the mesial-distal “swing” of the palatal root noted on the radiographs, the palatal root apex is probably a greater distance to the lingual than if the “swing” weren’t as dramatic. The axial inclinations, and/or any rotations of the tooth, also need to be noted. An examination of the patient’s palate can also aid in determining the anatomical inclination of the palatal root. A shallow palate may harbor a root that has a greater palatal inclination. On the other hand, if the palate is raised and steep, the palatal root can be expected to have less of a palatal inclination and would be closer to the buccal roots. If the tooth is crowned, the clinical examination has to determine if the molar is rotated, and in which

direction. This is sometimes difficult to see if the tooth has been restored with a crown, but often the “emergence form” of the cervical area of the crown can be of great help in making this determination. It is important to keep in mind that the buccal to lingual distance between the buccal and palatal roots can be very significant, because some of the instruments (ultrasonic tips for example) are not long enough to reach an apex that has an unusual palatal inclination. In any case, the surgeon should get as much information as possible before the apical surgery is started.

In the maxillary molars, either of the buccal roots can occasionally be fused to the palatal root (Fig. 34.96). In the process of performing the root-end re-

need to open into the sinus is one of them.

There are a few important concepts to keep in mind when performing the trans-sinus, or buccal approach to the palatal root, especially the first few times. Since the thickened bone around the zygomatic process as it comes into the maxilla is a concern when planning the surgical access, consideration needs to be given to making the access slightly more apical and mesial than normally for the buccal roots of that molar. In other words, the access for the palatal roots should be planned as a separate access, not the same as the access for the buccal roots (MB & DB). The two different access openings may merge into one larger opening, but they need to be different. The access for

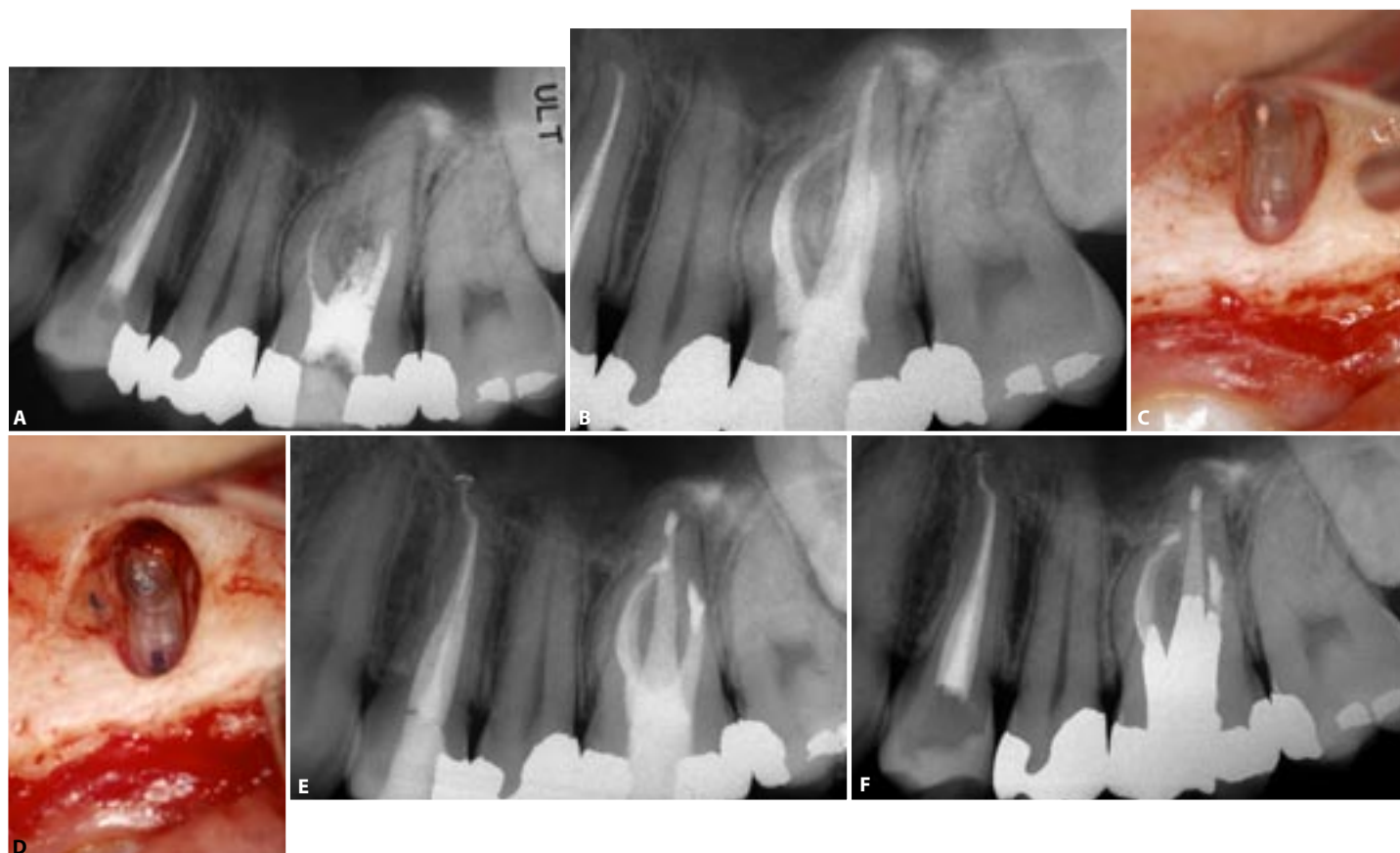


Fig. 34.96. **A.** Preoperative radiograph of the upper left first molar. The tooth needs a non-surgical retreatment. **B.** Post operative radiograph. After retreatment the tooth remained sensitive and surgery was scheduled. **C.** The disto-buccal and the palatal roots were fused and the bevel of the root involved also the palatal canal. **D.** The three retrofill in place. **E.** Post operative radiograph. **F.** Two year recall (Courtesy of Dr. Arnaldo Castellucci).

section on either of these roots can expose an isthmus leading to the palatal canal that must be prepared and sealed by means of a root-end fill. In any case, it is important for the surgeon to be prepared for any complication that can arise during apical microsurgery. The

the palatal root of the first molar should be adequately opened and centered more mesial than a normal access to the mesial buccal root of the molar would be. Doing this prevents the unnecessary additional apicectomy or beveling of the buccal roots in order to get vision and

access while instrumenting the palatal apex. Methylene blue staining is an important step so visualization of the root anatomy is uninterrupted, helping to prevent unnecessary tooth reduction (Fig. 34.97).



Fig. 34.97. The root-end bevels of the mesial-buccal, the distal-buccal and the palatal root have been stained with Methylene Blue to enhance vision (Courtesy of Dr. Gary Carr).

The apices of the maxillary teeth that do protrude into the sinus are usually protected by a layer of cortical bone, and the vessels and nerves associated with them are normally not affected as long as the bone is left intact over the teeth. In the event the sinus has to be entered, the surgeon should not be alarmed. On occasion, a large chronic lesion will be in, or near the sinus, and often the careful surgeon can visualize the snyderian membrane by its characteristic “blue-gray” color. As long as the membrane is still intact, sinus curettes (Fig. 34.98) can be utilized to gently “lift” the membrane inwardly and out of the way. Then after the surgical pro-



Fig. 34.98. Sinus curettes are helpful when manipulating the snyderian membrane within the confines of the maxillary sinus.

cess, the snyderian membrane remains intact and healing is more uneventful. If a material for guided bone regeneration is introduced into the defect, the snyderian membrane becomes a convenient barrier to have.

If the snyderian membrane is inadvertently penetrated, it rapidly “shrinks” from sight. This can be uncomfortable for the novice, but rest assured, it has not disappeared. The important thing is to prevent any debris from the surgical procedure from entering the maxillary sinus. This is effectively accomplished by “packing” the sinus to create a barrier for any debris created. The term “packing” is a poor choice of words! To “place” a barrier, a continuous piece of $\frac{1}{2}$ inch, plain, sterile gauze is used (Fig. 34.99 A). The $\frac{1}{2}$ inch gauze is removed in one continuous piece from the sterile bottle, as needed, and gently pushed into the sinus with the beaks of a small, curved hemostat, until a stable, but loose barrier is formed behind the root(s) being operated on (Fig. 34.99 B). The gauze is



A



B

Fig. 34.99. **A.** One continuous strip of $\frac{1}{2}$ ” plain, sterile gauze is used to gently “place” into the sinus to create a loose, but stable barrier. **B.** Small, curved hemostats are helpful to gently place the gauze strip into the sinus cavity.

then cut, leaving about ½" (1.0 cm) against the buccal plate of bone at a convenient edge of the opening to the crypt. A 3-0 suture is immediately tied to the free-end with at least 12" (30 cm) of the left "hanging out" so safe retrieval of the gauze is assured. The suture should be of adequate length so its availability and security is never in question. *Caution: Never use iodoform or Vaseline impregnated gauze strips as they can be very irritating to the sinus membranes and cause unnecessary complications.*

The full sulcular flap should always be used and extended more mesial than normal to accommodate a slightly more mesial access opening and allows for complete closure of the antra-oral opening post operatively. In general, the longer a flap is (mesial to distal) the easier it is to manipulate. When the maxillary sinus is exposed, the complete closure of the access opening with the appropriate flap design may be the single most important factor leading to uneventful post surgical healing. The snyderian membrane has good potential for healing and is not of great concern when operating in the area of the palatal root apex. Prophylactic antibiotics, such as Amoxicillin or Keflex, can be prescribed post surgically if necessary, but normally this is not indicated.²⁰ Post-operative instructions to the patient should include the following points:

1. Do not blow your nose for one week.
2. Take antibiotics and other medications as directed and for as long as directed.
3. Avoid hard coughing or suppressing a sneeze, which may increase the air pressure in the sinus.
4. If you must sneeze, open your mouth wide and sneeze through your mouth.
5. Do not smoke, or use a straw, for one week.
6. Eat a softer than normal diet for 3-5 days. Especially things like popcorn, nuts, chips, etc. must be avoided.
7. Commonly a bloody discharge from the nose may be present for a few days.

Pre-surgical restorations

In the event the tooth being endodontically treated requires either periodontal surgery involving a root amputation, or root end resection (RER) with a root end filling (REF), a pre-surgical restoration can be placed prior to the procedure. This eliminates the post surgical necessity of a restoration in the case of a root amputation, or a REF after an apicoectomy.

Prior to Root Resections

The materials used to pre-restore a root resection can be any bonded restorative composite or a fluoride releasing glass ionomer cement such as Geristore. The involved canal is instrumented to approximately one-half the length of the root (well past the intended resection line) and opened large enough to accept the desired filling material. The pulpal walls, proximal to the orifice of the root to be resected, are prepared for adequate retention of the material used to seal the prepared canal. If there are two canals in the root to be resected, the isthmus must also be prepared and filled. When the root is resected, the filling material is trimmed leaving the canal(s) sealed and no further restoration is necessary post surgically.

Prior to Root End Resection (RER)

In endodontic treatment, the presurgical REF should be considered whenever possible to greatly simplify the process. One of the best indications for the presurgical REF is when apical surgery is planned for a difficult apex to access (the palatal apices of maxillary molars and apices of lower second molars). The difficulty of creating an anatomically correct REP and placing a REF in these areas is a well-known problem. If the REP and REF steps can be eliminated and the apical surgery be reduced to just an apicoectomy, much of the time, difficulty and stress are eliminated from the procedure.

The canal is instrumented as close to the terminus as possible, and large enough to permit the placement of a filling material to the apical confines of the preparation. By necessity, the canals are instrumented to a larger file size in order to allow for the placement of the material. The fundamental reason for apical surgery is usually due to persistent infection of the root canal space.^{10,24,26} Therefore, it is important that all treatment be directed at eliminating bacterial infection from within the REP. The use of either 17% EDTA, 10% citric acid, 35% phosphoric acid, or MTAD, followed by irrigating with 2% CHX will decrease bacterial load and increase the predictability of success.^{18,50,51} Before placement of the pre-surgical REF, temporarily filling the prepared canal space with calcium hydroxide (Pulpdent, Watertown, MA, USA or UltraCal XS, Ultradent, Salt Lake City, UT, USA) for a minimum of 7 days, has been demonstrated to reduce contamination of the dentinal tubules in the canal walls and will also increase predictability of complete healing.^{6,35,62}

The material of choice for the presurgical retrofill is mineral trioxide aggregate (MTA). However, Super EBA, IRM or bonded composite can also be used, but not as easily. The MTA is best placed using a Dovgan Carrier loaded with a 2 to 3mm "pellet" of MTA. The MTA is then "pushed" into place and gently "*persuaded*" to the apical confines of the prep with the appropriate pre-fitted and pre-measured plugger. After the first pellet is placed, a radiograph should be taken to verify the MTA is as far apically as desired and no voids are present. The apical 6 to 8 millimeters should be filled so there is at least 3mm left for an adequate seal, after the RER is completed.

To achieve a denser fill, ultrasonics can be used to eliminate air and/or water from the MTA after placement. With the ultrasonic at its lowest power setting, the assistant just touches the tip to the non-working end of the instrument being used by the operator (Fig. 34.90 A). It is only necessary for the instrument to just be in contact with the MTA to achieve "densification". This technique is most effective if gravity is working in our favor (best on mandibular teeth). If the MTA is too moist, excess water can be removed easily with the thick end of a medium or coarse paper point that fits to the coronal portion of the MTA (Fig. 34.100).

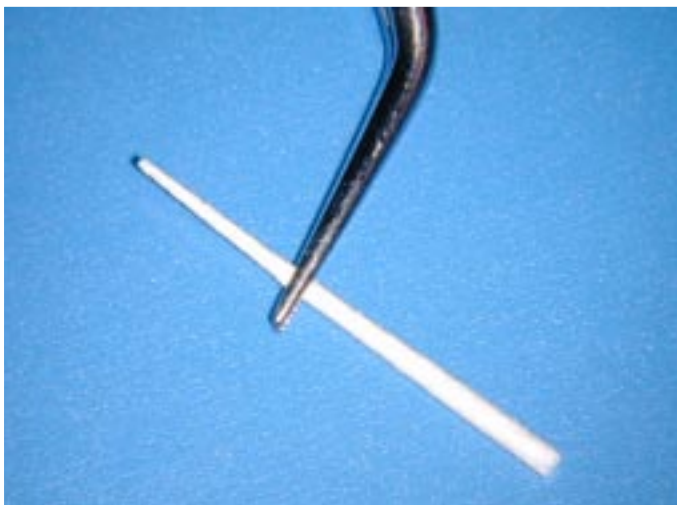


Fig. 34.100. If the MTA is too wet, the thick end of a fine, medium, or coarse absorbent point held in the beaks of cotton pliers can "wick" excess moisture.

Whenever possible, it is desirable to seal in a moist cotton pellet for 24-48 hours. This will allow the hydrophilic MTA achieve better adaptation to the walls of the preparation and acquire optimum properties during the setting process.⁶³ Ideally, the apical surgery should be delayed until at least 24-48 hours after placement of the MTA to insure it has completed the setting process. After confirming the set of the MTA is complete, the final seal of the coronal portion can be completed by the operator to "seal the rest of the canal system". ***It is imperative that the entire coronal portion of the canal system be sealed with the final coronal build-up, or foundation restoration. To do apical surgery without the complete sealing of the entire canal system would decrease the predictability of the healing process.***

Since the MTA does not adhere to the walls of the preparation, it is suggested the apiectomy should be done with as little vibration as possible. An 1171 surgical length bur (Brasseler) has spiral flutes and is well suited for smooth cutting and beveling of the apiected surface (Fig. 34.47). Diamonds also offer a vibrationless and efficient cutting action, but enough irrigation must be used to ensure the bur doesn't get clogged with debris that can cause unfavorable overheating. *As long as the simple precautions mentioned above are taken, the resection should not affect the seal of the "set" MTA.*²

Surgical Repair of Perforation or Resorption Defects

If there is an iatrogenic or resorptive perforation of the canal system, and access is possible, it is a relatively easy procedure to correct the defect surgically. However, considerable thought must be given to the timing of the repair. In many situations, the surgical repair is wisely scheduled to be performed after the conventional endodontics is completed. By doing this, the doctor has an opportunity to consider repairing the perforation non-surgically, thereby avoiding unnecessary surgical intervention. In the case of the filling material extending into the soft tissues, surgery may be the only effective way to debride the area and provide an adequate seal and repair of the defect.

After all considerations are given, and surgical repair of the defect is to be performed, a full sulcular flap is recommended to gain access to the per-

foration (Fig. 34.101 A). Either burs or ultrasonic tips can be used to prepare the defect. In some cases, it is necessary to remove bone from the mesial or distal, to gain access for the margin of the final restoration (Fig. 34.101 B). In some cases, a slight amount of bone needs to be removed and usually some recontouring of the osseous architecture (Fig. 34.101 C). The preparation is etched with a blue etchant gel (Ultradent) for 15-20 seconds (Fig. 34.101 D). After rinsing and drying, the dentine should have a “duller” appearance than the surrounding “unetched” dentine (Fig. 34.101 E). Great care must be taken to not dry the dentine too much. Bonding has been shown to be stronger when the dentine is just dry enough so there isn’t any “pooling” of water left from the rinsing of the etchant. If the dentinal tubules are too dry, they will collapse and not allow the conditioner to penetrate as deeply as desired for better retention. Tenure

A & B (Den-Mat) is now placed as a dentine conditioner with a small brushes or micro applicators (Ultradent or Vista), lightly dried with air, and another coat is applied (Fig. 34.101 F). More conditioner is applied until the surface appears “wetted”. Usually, two applications, or coats, are all that is necessary. The dentine conditioner is an “unfilled” resin that permeates deep into the dentinal tubules after the etching process, providing a stronger bond between the composite and the dentine. The Gerestor is applied in layers if the defect is large, but often a single layer will suffice. The material is light cured for the appropriate amount of time, depending on the strength of the curing unit used (Fig. 34.101 G). The restoration is contoured with composite burs and polished with rubber point to achieve a very nice marginal integrity (Fig. 34.101 H). Another example shown is the repair of an iatrogenic perforation on the buccal, mid-ro-

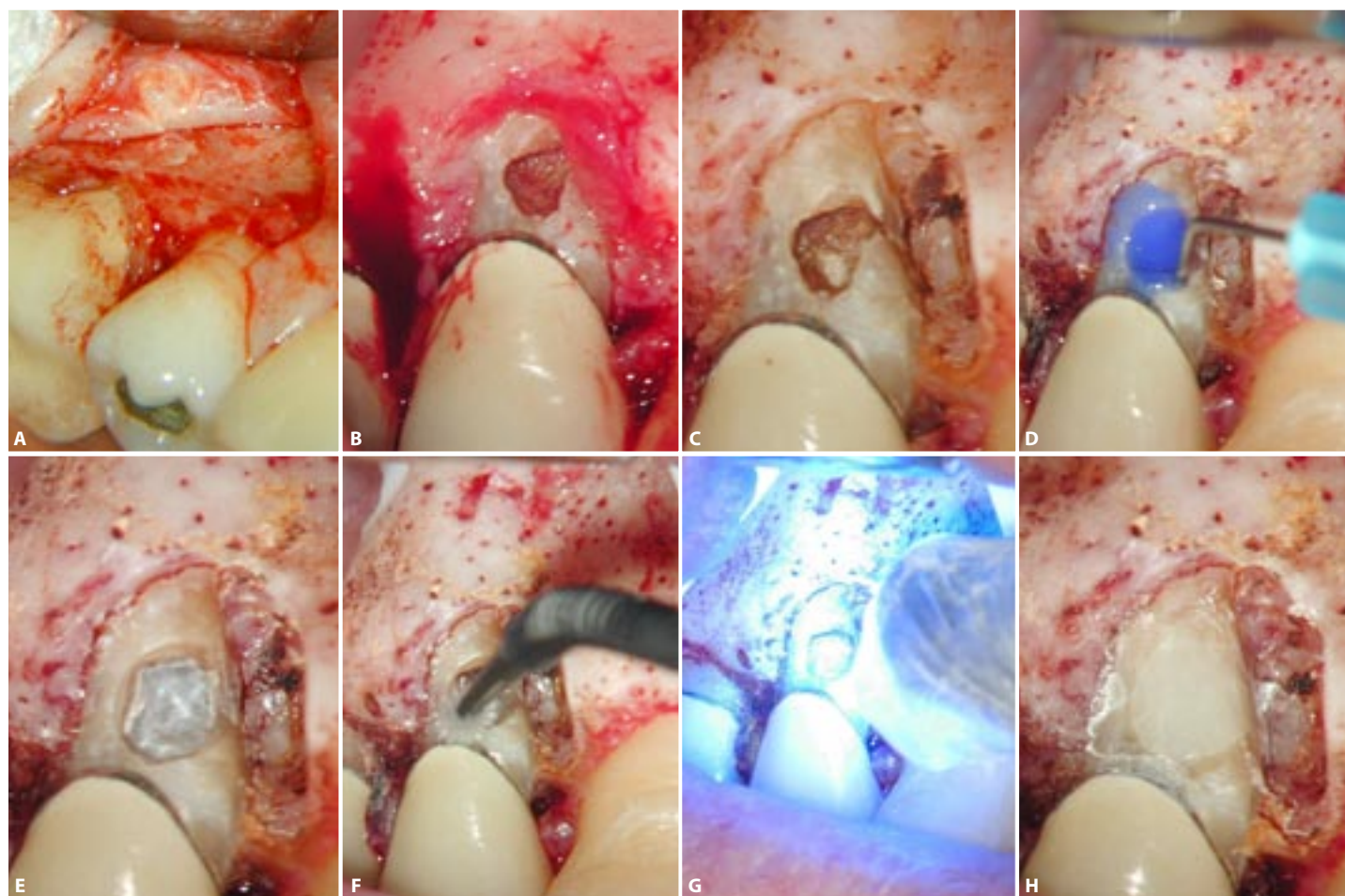


Fig. 34.101. **A.** A full sulcular flap is used to repair all root defects. **B.** Access is achieved to the defect. **C.** Bone recontoured to expose the mesial margin and prepared using burs or ultrasonics. **D.** Blue etchant gel (35% phosphoric acid) is applied to the preparation for 15 - 20 seconds. **E.** When rinsed and dried, the dentin has an opaque appearance prior to placing the conditioner. **F.** Two coats of dentin conditioner (Tenure A & B, Den-Mat, USA) are applied with a micro-applicator. **G.** The dual cure Geristore is light cured to begin the rapid setting process. **H.** The final restoration exhibits good marginal integrity.

ot, of the mesial root in a lower first molar (Fig. 34.102). The glass ionomer is very compatible to the tissues and easy to work with. In both of these instances of root defect repairs, Geristore (Den-Mat) was the restorative material of choice. It is flowable, dual cure, simple to use, and has been shown to be very compatible with the periodontal tissues.⁶¹ However, the surgical repair of a root defect should always be considered a last resort. All nonsurgical modalities of treatment should be considered before surgical repair.



Fig. 34.102. A repair of a mid-root iatrogenic perforation on the buccal of the mesial root of a mandibular first molar.

Guided Bone Regeneration (GBR)

Materials for GBR

The routine use of GBR in endodontics is gaining in popularity, but this rapidly growing area is ever changing. Numerous products are available for GBR in apical surgery. Some examples are Guidor, autogenous grafts, Pepgen-15, Freeze Dried Bone (both demineralized & mineralized), Grafton, Osteograft N-300, Bio-Oss, Tefgen, Laminar, Hydroxyapatite, BoneGen, and SurgiPlaster, just to name a few.

Combining some of the materials together is a common practice. The following case, illustrates the healing that can be achieved using combinations of osseous regenerating materials (Fig. 34.103 A). This case presented with deep probing of more than 10mm on all surfaces but the mesial-lingual, lingual, and distal-lingual sulcus. The full sulcular flap was retracted and the entire lesion thoroughly curetted. It was quickly apparent that only the lingual surface of the root was in contact

with the lingual plate of bone. The long standing lesion had destroyed all other boney support. The tooth was so mobile; it had to be held in place during the entire apical microsurgical procedure. The situation appeared hopeless, but the patient desperately wanted to save the tooth if at all humanely possible. The apices were beveled, REP made and REF with MTA. A combination of Bio-Os and Guidor was used for GBR and the case was sutured (Fig. 34.103 B). The follow-up radiographs illustrate complete healing (Figs. 34.103 C, D).



Fig. 34.103. **A.** Pre-op radiograph of desperate attempt to salvage this mandibular first molar. **B.** Immediate post-op of apical microsurgery using Bio-Os & Guidor for guided bone regeneration. **C.** 6 month follow-up radiograph. **D.** 2 year post-op radiograph demonstrates complete healing.

Calcium sulfate (CS)

Calcium sulfate is becoming one of the most practical all-around materials to use if a soft tissue barrier, or GBR, is indicated for the endodontic surgery. Calcium sulfate has become a popular adjunct for endodontics because it can be used in nonsurgical procedures as well, using it as a matrix for perforation repairs is just one example. The average defect after apical surgery lends itself to uncomplicated procedures. In fact, on many occasions a soft tissue barrier, or GBR, is not even necessary. The blood clot itself is sufficient to allow normal, uneventful and complete healing to occur. However, in large lesions approximating one centimeter and larger, or if there is a dehiscence, the GBR is necessary to prevent the invagination of epithelium and allow bone formation.

If CS is to be used as a soft tissue barrier, or GBR, and intended to be left in after surgical closure, it must be carefully screened for naturally occurring impurities such as silicates, lead, strontium and fillers such as silicates and/or cellulose (wood) fibers. Medical grade CS must be used and is available under the brand names BoneGen by Orthogen (USA) and SurgiPlaster by ClassImplant (Italy).

Properties of calcium sulfate

The CS begins as gypsum that is mined from the earth as calcium sulfate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). The water of hydration is driven off with controlled heating in a process called *calcination* and forms a hemihydrate ($\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$). When the proper amount of water is added, it causes setting to form calcium sulfate dihydrate. The two forms, alpha and beta, clinically demonstrate similar bone regeneration results.

Mechanism of action and chemistry of calcium sulfate

The easiest way to imagine how CS works is to imagine it as a piece of “hard candy” in the crypt. As the hard CS is dissolved in a bone-healing environment, calcium phosphate deposits form in the adjacent soft tissue. This mineral, which was probably a biological apatite, appears to form as calcium ions are released from the CS upon reaction with body fluids. In vivo, these deposits became incorporated into ingrowing bone and were observed to be osteoconduc-

tive. This strongly suggests that CS acts as a resorbable calcium-releasing substrate that produces a calcium phosphate lattice in adjacent tissue and is an osteoconductive matrix for bone ingrowth as it dissolves and recedes.⁵³

The advantages are: 1) it is easily stored, 2) requires no special armamentarium, 3) can be placed in an enclosed defect, 4) a safe and effective biomaterial for bone defect filling applications, and 5) has been used successfully for over 100 years.

There are two main disadvantages: 1) CS does not perform well in the presence of blood and, 2) in some cases it resorbs too rapidly. When blood is present, it infiltrates the material and drastically prolongs the setting time. Blood also adversely alters the mechanical and dissolution properties.⁵⁴ However, by using less water, adding accelerants like NaCl or K_2SO_4 , creating a “drier mix”, and keeping the bone site as free of moisture as possible, the disadvantages can be minimized. If “pre-set granules” of CS are used, the dissolution time can be extended allowing more time for bone formation.

The following illustrations (Figs. 34.104 A-G) demonstrate the rapid healing and usual radiographic response to GBR using CS to fill the crypt during apical microsurgery on tooth # 1.2. This tooth was treated in two visits, but was not responding favorably. A radiograph (Fig. 34.104 A) taken immediately before apical microsurgery, shows a remnant of calcium hydroxide remaining from intra- appointment medication. After the MTA-REF was placed, a Dovgan Calcium Sulfate Carrier (Quality Aspirators) (Fig. 34.104 B) was used to inject CS into the 1 cm. defect (Fig. 34.104 C). The crypt was filled with CS and excess trimmed flush to the level of the facial bone surface (Fig. 34.104 D). The case was closed routinely and the sutures removed in 48 hours. The patient was recalled 5 days post-op. The follow-up radiograph demonstrated a very slight resorption at the periphery of the CS (Fig. 34.104 E). Little change was observed at the 10 day post-op (Fig. 34.104 F). At the beginning of the third week, 17 days after surgery, there was a noticeable change in the amount of resorption at the periphery (Fig. 34.104 G). However, at the one month post-op recall, there was marked peripheral dissolving and there appeared to be beginning calcification of the bioactive calcium phosphate lattice left as the CS is resorbed (Fig. 34.104 H).⁵⁴ The four month post-op showed complete disappearance of the CS material and definite calcification of the periphery of the defect left by the cyst (Fig. 34.104 I). At seven months, there is more calcification and bone ingrowth and into the osteoconductive matrix (Fig. 34.104 J-O).

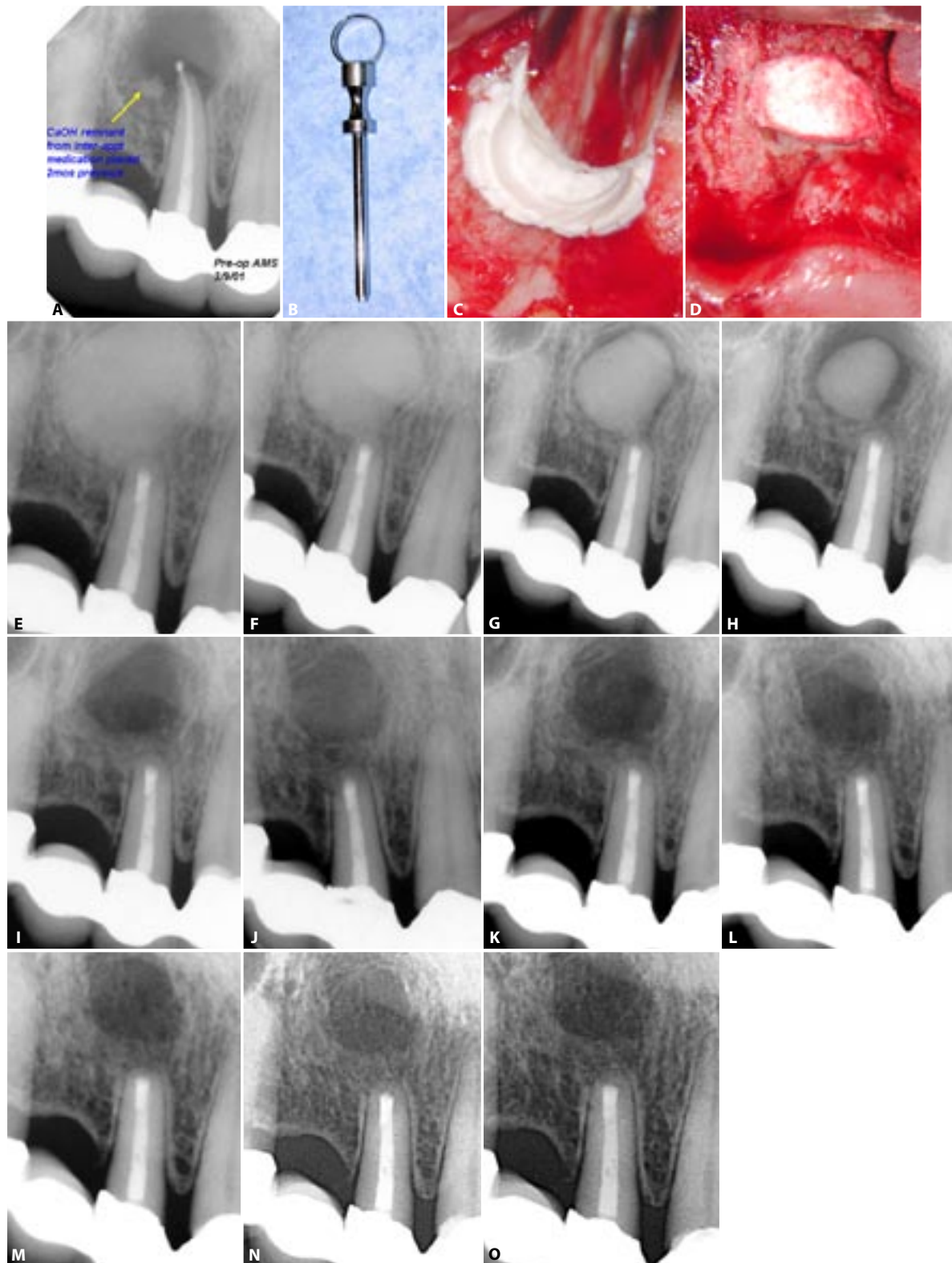


Fig. 34.104. **A.** Immediate pre-op radiograph showing poor response to all nonsurgical Retreatment attempts. **B.** The Dovgan Calcium Sulfate Carrier permits efficient and accurate placement of CS into the confines of the crypt. **C.** Calcium sulfate filled crypt and excess trimmed to normal facial bone surface to match normal anatomy of area. **D.** The crypt has been filled to the buccal plane. **E.** 5 days post-op, only slight peripheral dissolution of CS is noted. **F.** 10 days PO, not much more change in periphery of CS noted. **G.** 17 days PO, more noticeable peripheral dissolution of CS is seen. **H.** At 1 month PO, there is marked dissolving of the CS. **I.** After 4 months PO, the CS has completely dissolved. **J.** At the 7 months PO, beginning bone ingrowth of osteoconductive matrix is seen radiographically. **K.** 9 months PO. **L.** 19 months PO. **M.** 30 months PO. **N.** 42 months PO, the 'through-and-through' lesion is clinically healed and asymptomatic. **O.** 51 months PAX, and final PO indicates a successful result.

Section 6: Sutures and Suturing Techniques

Closure of the Surgical Flap

All steps have been meticulously followed, the root-end fill has been placed, the crypt is clean and re-filled nicely with blood, the final radiograph has been approved and it is time to suture the flap into position. Sadly, most operators now push the microscope aside and suture without it. To do this robs the operator of an opportunity to demonstrate to themselves, and their patients, the amazing capabilities of the SOM. The doctor must make a commitment to master the suturing technique using the SOM. It will never be accomplished with the SOM pushed aside at this critical step in the apical microsurgical procedure. It has been said, “You have ‘arrived’ if you can suture ‘under the scope’”.

When the surgical site is ready for closure, the flap should be gently massaged to close approximation with the osseous surface and the attached tissue and compressed with a folded, moist, sterile 2” X 2” gauze. If the initial incision was planned with this final step in mind, the tissues should re-approximate without any problem. Now is when the operator will appreciate creating nice “scalloping” when designing the incision. Remember the old saying, “Hindsight is always 20/20”. Due to possible slight shrinkage of the flap during surgery, it may be necessary to use the edge of a small #2 mouth mirror to hold the tissue in position while the second surgical assistant (the chief assistant on the same side of the chair as the doctor) hands the doctor the needle holder with the suture.

All suturing is accomplished using 6-0 black monofilament nylon (Supramid, S. Jackson) or 6-0 green polyester (Tevdek, CK Dental Specialties) (Fig. 34.105). Some micro surgeons are using 8-0 and, even 10-0; but the 6-0 is stronger, and doesn't tear through the tissue as readily. The results are no different than with the more difficult to use, smaller needles and thinner suture. Keep in mind, the sutures will be removed in 24hrs so it is really a mute point as to whether the suture is 6-0, 8-0, 10-0, or the needle is a little smaller in diameter. The results achieved with 6-0 suture seem to be well suited to apical microsurgery. The black silk suture, traditionally used in surgery, is a detriment to the rapid healing we are trying to achieve. Not only does the plaque accumulate much quicker on it (Fig. 34.106), but also, the braiding acts as a wick for the migra-

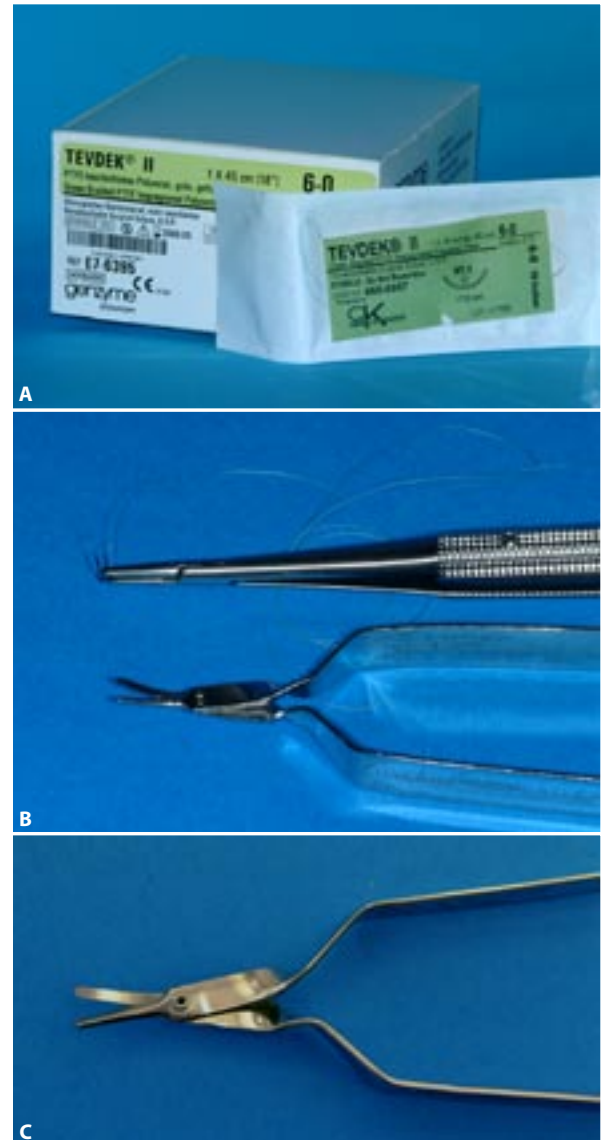


Fig. 34.105. **A.** Tevdek 6-0 polyester suture (CK Dental Specialties). **B.** The Castro-Viejo needle holder and the EH Suture Scissor (Practicon). **C.** This scissor have blunt blades and sever the suture from above, without cutting underlying tissue.

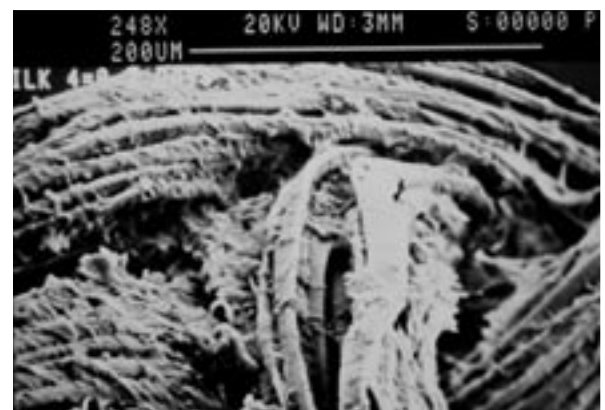


Fig. 34.106. The black silk suture accumulates bacterial plaque very quickly (Courtesy of Dr. Gary Carr).

tion of bacteria into the wound resulting in increased inflammation and compromised healing. The type of needle used depends on the type of flap to be sutured.

For the *Luebke-Ochsenbein Flap* (also called a *Muco-Gingival* or *Submarginal Flap*), a taper point needle (TPN) 3/8 circle attached to monofilament 6-0 suture (Supramid, S. Jackson, code MEA-60B) or to a 6-0 Tevdek suture are used. The TPN is superior to the reverse cutting type needle (RCN) because there isn't the tendency to cut, or tear, the "beginning" and "exiting" needle points. As a result, the TPN is easier to guide through the tissues to a more accurate exit point when suturing the flap. They just seem to co-operate more when suturing this type flap! One of the nicest things about using this flap design is the ability to easily demonstrate the healing that has taken place in only a day and the absence of scarring afterwards (Fig. 34.107).

For the *Sulcular Flap*, a reverse cutting needle (RCN), 3/8 circle (Supramid, S. Jackson, code MPR-

60B) is used. This needle was chosen because the larger size facilitates passing it through the contacts when doing a sling, or mattress suture. The sling suture is routinely used to save time on closure, rather than doing individual buccal to lingual sutures. On many occasions, the smaller TPN may also be used to suture the attached gingival area of the flap at the coronal aspect of the releasing incision.

Suturing Technique Using the SOM

To permit greater peripheral vision, the SOM should be set at a lower power than has been used for the rest of the microsurgical procedure. A magnification between 2.5X and 4.5X will usually be optimal. Using a small Castro-Viejo type needle holder, the beaks of the holder should be grasping the needle approximately 3/4ths of the distance from the pointed end and perpendicular to the axis of the needle. It is important to keep the beaks of the holder away from either end of the needle, as this is the area of its greatest weak-



Fig. 34.107. **A.** The Luebke-Ochsenbein Flap has been sutured with 6-0 Tevdek. **B.** The suture has been removed after 24 hours. **C.** Nice healing after 15 days. **D.** Three year recall: complete absence of scarring (Courtesy of Dr. Arnaldo Castellucci).

ness and can distort, or break easily (Fig. 34.108 A). Grasping the needle in this manner, gives the operator the most safety and control over its direction, stability, and integrity (Fig. 34.108 B).

For the sake of simplicity, the following descriptions will primarily address a surgeon that is right-handed. The left-handed surgeon will refer to the right or left in the parenthesis. Thus, a left-handed surgeon will have to substitute right for left, and left for right as indicated. While grasping the needle holder in the doctor's normal working right (left) hand (remember to use the parenthesis if you are left-handed), the needle is passed through the desired entry and exit points on both sides of the incision, always going from unattached to attached tissue. Then, after regrasping the emerging end of the needle, pull it through both sides of the incision with the needle holder in the right (left) hand and deliver the needle so it can be grasped between the thumb and index finger of the other hand (Fig. 34.108 C). As the doctor is doing this, the second assistant (the "flight director") is taking hold of the end of the suture with their thumb and forefinger (cotton pliers or a hemostat can also be used) so it won't inadvertently be pulled through the tissues. Now the doctor "winds", or "twirls" the suture 3 or 4 times around the beaks of the holder to begin making the first knot and to create tension for the "gathering" of the suture (Figs. 34.108 D, E). As the doctor is making these "twirls", the second surgical assistant is placing the end of the suture into the doctor's visual field of the microscope, so the end of the suture can be easily grasped in the beaks after the "looping" or "winding" to make the knot is completed. In this way, the suturing can be accomplished with little movement in the relatively small field of vision present with the SOM (Fig. 34.108 F, G). The surgeon now grasps the end of the suture with the beaks of the holder and starts drawing the suture to take up the slack (Fig. 34.108 H). The "loops" around the beaks of the needle holder aren't "slipped" off the end of the hemostat yet. The "loops" are left on to create just enough friction to maintain a slight amount of tension between the doctor's hand (the hand holding the needle) and the beaks of the needle holder in the right (left) hand. Care must always be taken that the tension is only between the left (right) hand and the needle holder, and not exerted on the tissue. The purpose of maintaining this tension is to give the doctor positive tactile sense when taking up the "loops" of excess suture material in the left (right) hand. As the suture is taken through the tissue, the needle holder

is raised with the right (left) hand while the left (right) hand descends as it gathers up the slack (Fig. 34.108 I). As the suture is gathered in the left (right) hand, the holder "descends" to relax the tension and allows more suture material to be pulled through the tissue with the left (right) hand (Fig. 34.108 J, K). It is an alternating "up-and-down" rhythm of movement that is difficult to describe in writing, but is actually very easy for the beginning microsurgeon to learn.

The "loops" are now slid off the beaks of the Castro-Viejo forceps and the "surgical knot" is started. The first "positioning knot" of 3-4 "loops", is tightened until the two edges of the incision are gently approximated. The second, or "securing knot", of 1-2 "loops" is now placed to secure the positioning knot. It is important to anticipate the further tightening effect the securing knot may have on the tightness of the suture. Then, after the operator is satisfied with the tension of the suture, the third "locking knot" is placed.

The second surgical assistant now takes the Castro-Viejos from the doctor, replacing it with the micro-scissors, and the suture is cut as close to the knot as practical (Fig. 34.108 L). After the second assistant takes the scissors and the suture, the doctor is handed a micro-forceps so the knot can be moved as far away from the incision line as possible, preventing plaque build-up over the incision. Note when moving the knot with the micro-forceps, it is important that the knot be pushed to place, not pulled to place, always keeping the knot between the micro-forceps and the final point where the knot is to be. Pulling the knot can loosen, or untie the suture, especially if the knot isn't as tight as desired (Fig. 34.108 M-O). Doing this ensures the knot doesn't inadvertently get untied and its original integrity is maintained until removal.

Suturing Considerations

One of the most common mistakes made when suturing is to overly tighten the suture. It is better to make it a little too loose than too tight. A tight suture can cause a crushing and/or ischemic injury, possibly compromising rapid and uneventful healing we can normally expect. When making a sling or continuous suture in a sulcular flap, it is easy to be too aggressive when tying the knot, causing the other end to get too tight. So the tightness of all of the loops along the entire length of the suture should be checked before completing the securing knots.

The *releasing* incision is usually an integral part of every flap and may be considered differently from the

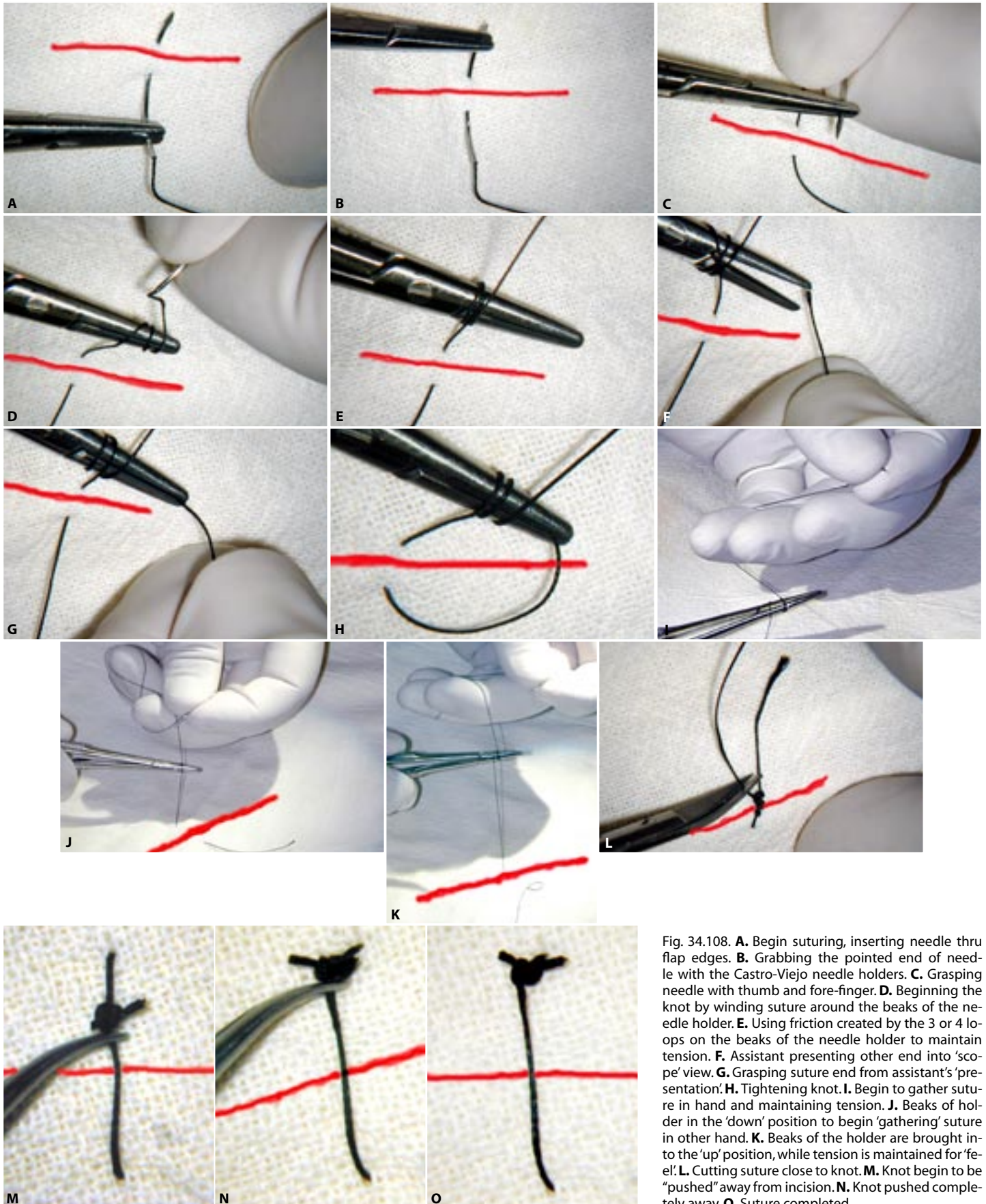


Fig. 34.108. **A.** Begin suturing, inserting needle thru flap edges. **B.** Grabbing the pointed end of needle with the Castro-Viejo needle holders. **C.** Grasping needle with thumb and fore-finger. **D.** Beginning the knot by winding suture around the beaks of the needle holder. **E.** Using friction created by the 3 or 4 loops on the beaks of the needle holder to maintain tension. **F.** Assistant presenting other end into 'scope' view. **G.** Grasping suture end from assistant's 'presentation'. **H.** Tightening knot. **I.** Begin to gather suture in hand and maintaining tension. **J.** Beaks of holder in the 'down' position to begin 'gathering' suture in other hand. **K.** Beaks of the holder are brought in to the 'up' position, while tension is maintained for 'feel'. **L.** Cutting suture close to knot. **M.** Knot begin to be "pushed" away from incision. **N.** Knot pushed completely away. **O.** Suture completed.

rest of the incision. Normally, the releasing incision is not necessary to be sutured, but if it is, the suture should be slightly looser than those in the attached gingival tissues. Very close approximation of the incised edges is not necessary in the releasing incision.

It has been shown that *epithelial creep*, or *streaming*, occurs rapidly, or at a rate of about 1mm per side per 24 hrs.⁵⁶ In other words, a wound with edges separated 2 mm would be expected to come together within a 24 hr period. In hundreds of surgeries over the past nine years, there were only a few occasions the releasing incision wasn't completely closed without any sutures at all. Of those few that didn't close within the 24 hr period, all closed within 48 hrs.

To repeat: if the operator prefers to suture the releasing incision, it should be sutured loosely to allow for swelling, or else the suture will present itself buried in the tissue and some tearing may occur (Fig. 34.109 A, B). The result will be a more difficult suture removal for the surgeon and increased discomfort for the patient.

Another consideration is to be sure to suture to like tissues to like tissues. In other words, suture attached gingiva to attached, and unattached to unattached. Never suture attached gingival tissue to unattached gingival tissue, since the suture will tend to pull out of the attached side. When suturing the properly designed incisional wound after endodontic surgery, this should never be a problem.

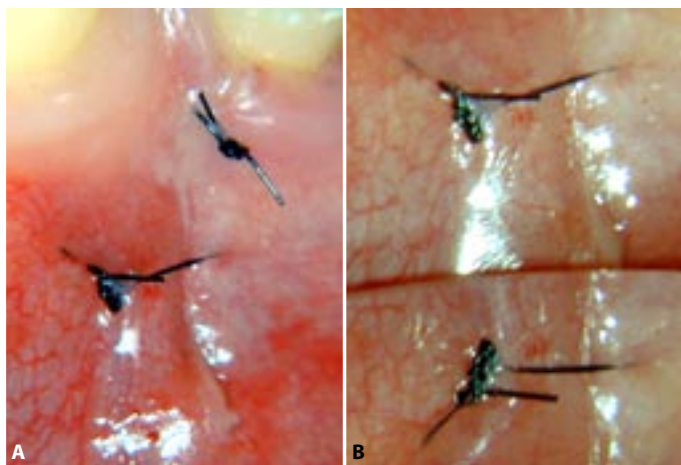


Fig. 34.109. **A.** Tight suture - 24hr shows a tendency to get "buried" into, and "tear" the tissue. **B.** Tight suture-mirror view (same suture) makes a more difficult, traumatic, and uncomfortable suture removal visit.

Flap Tissue: Re-approximation Management

Immediately upon completion of suturing, a folded 2" X 2" piece of moistened, sterile gauze is again used to gently compress the flap and create as close approximation as possible between the incisional and dissectional wound surfaces as possible. This close approximation of the surgical wound promotes rapid healing by permitting a thin fibrin clot in the dissectional wound and better initial adhesion between the wound edges.²⁹ If there are some minor discrepancies in the reapproximation of the flap edges, a gentle "massaging" of the tissues can slightly move the flap into a better position and achieve better approximation.

24 Hour Suture Removal

It is very important to consider the nature of the endodontic surgery access incision and how it differs from periodontal surgical incisions. Basically, the endodontist is dealing with healthy tissues and attachments, depending on healing by *primary intention*. The periodontist, on the other hand, is dealing with diseased tissues and attachments, and depending on healing by *secondary attachment*. If the tissues are healthy and atraumatically handled throughout the entire surgical procedure, and the incision is closely approximated, primary intention healing will take place. The following case is typical of the normal post-surgical sequela (Fig. 34.110 A-C). The *epithelial bridge* and subsequent *collagen cross-linkage* is normally completed within 18-24 hours. If this is true, the sutures have completed their task, and in fact, are now a foreign body that can cause irritation and excessive inflammation, resulting in a retardation of the healing process and possible scarring. If the SOM is utilized during the entire suturing process, the incision can be closed accurately with extremely good approximation. It is because of well-planned, nicely scalloped incisions, atraumatic flap elevation procedures, and the very close repositioning of the flap with thin, hair-like, 6-0 sutures that routinely allow suture removal in a 24 hr period (Fig. 34.110 D, E). As a result there will be little, or no, resulting scar tissue formation (Fig. 34.110 F-I). The previous case is typical of what can be expected, if all steps are followed without exception.

For those that doubt the **24hr Suture Removal Theory**, an easy exercise is as follows: At the next surgery, be sure to place at least five sutures. After 24 hrs, have the patient in and remove **the worse looking suture**, the one you think isn't healing as well as the



Fig. 34.110. **A.** Immediate PO sutures. **B.** 24 hour PO, sutures before removal. **C.** 24 hour PO sutures #7 & 8, high magnification. **D.** 24 hour sutures immediately after removal. **E.** 24 hour sutures removed #7 & 8 high magnification. **F.** 3 days PO visit. **G.** 5 days PO surgery. **H.** 10 days PO surgery. **I.** One month PO, demonstrating very favorable healing typically expected using atraumatic techniques.

others. Then, the next day, remove **the next worse looking suture**. Then the next day do the same, and so on. At the end of the fifth day, **the worse looking suture** will be the one remaining! If that doesn't convince you, nothing will! With atraumatic techniques, close tissue re-approximation, and 24 hr. suture removal you can easily guarantee the patient that, "The scar won't show when you wear your bikini!". Except for a few medically compromised patients, the author has routinely removed sutures after 24 hrs in hundreds of surgeries, without complication. If for convenience sake, the sutures are left in an extra day, or two, there is no problem (Fig. 34.111). But, sutures left in for five or more days will usually exhibit unnecessary inflammation and delayed healing, probably due to either a foreign body reaction and/or bacterial invasion. The peak tissue reaction to the sutures occurs between the second and seventh day, so sutures should be removed before this peak response occurs.²²



Fig. 34.111. The patient could not come back for suture removal before the fifth day after surgery was completed. Note the complete absence of plaque around the Tevdek suture. (Courtesy of Dr. Arnaldo Castellucci).

Post Operative Care

Post operatively, the usual result is very little pain or swelling. The amount of discomfort and swelling is considerably less than that normally observed with the old apical surgery protocol. The postoperative instructions are:

- 1) ice packs to the area “twenty-minutes-on-and-twenty-minutes-off” for the first six hours,
- 2) gentle rinsing with Peridex twice a day for the next three days,
- 3) have sutures removed at the next appointment, usually within the next day or two.

A non-steroid anti-inflammatory is normally prescribed for the next three or four days as described below. Antibiotics are not usually prescribed unless indicated by the patients past medical history and/or surgical complications.

Many clinical studies have shown the use of non-steroid, anti-inflammatory drugs (NSAIDs) to be effective as a post surgical analgesic. Acetaminophen and ibuprofen are two of the most commonly used NSAIDs. Of the NSAIDs, ibuprofen 400 mg has been shown to be the more effective than aspirin 650 mg or acetaminophen 600 mg.¹¹ Ibuprofen 600 mg (Motrin, Upjohn) is normally prescribed if the patient has no allergy or adverse reaction to it. A cross allergy usually exists between ibuprofen and aspirin, so a patient allergic to aspirin is likely to also be sensitive to ibuprofen. In such cases, acetaminophen (Tylenol) is prescribed. Ibuprofen has also been shown to be more effective than a combination of aspirin and codeine. However codeine does add a small amount of additional analgesia when used in combination to ibuprofen.¹²

Occasionally, the patient will need something stronger than Ibuprofen 600 mg every 6-8 hrs, but it is the exception, rather than the rule. An effective variation of the regimen, for the patient that is not allergic to NSAIDs, is take the ibuprofen as prescribed, but along with the ibuprofen doses, take acetaminophen 400 mg. (Tylenol). For the patient that does have a very low pain threshold level, stronger analgesic or narcotic medications are considered and prescribed at the doctor's discretion. If pain medications are required, a good regimen is to have the patient take the NSAID first, and then 3 hrs later take the pain medications along with the Tylenol. Then every 6 hrs repeat the cycle for at least the next 2-3 days. Then, if all is well the patient can do the same cycle every 8 hours for 1-2 more days. The patient is advised that all NSAIDs can be stopped once comfort has been

achieved. Another very effective protocol is the use of Motrin 600 mg. used alternatively with hydrocodone 5mg. When all three medications are used in combination, the patient receives three possible pathways of pain relief: 1) the ibuprofen (Motrin) effect; 2) the acetaminophen (Tylenol) effect; and 3) the narcotic (hydrocodone) pain relief effect.

Although the use of steroids are an accepted method of medication after surgery, the author has never found the need for their use due largely to the proven effectiveness, low cost, availability, patient tolerance, and safety of the NSAIDs.

A word of caution: “Beware of the patient that expresses that “only Percodan”, or “only Percocet” (or other named drug) works for them”. This is especially true, if the medications are requested prior to surgery. Postoperatively, if all healing appears to be within normal limits, and there is no reason to expect undue amounts of pain, it is wise to avoid the indiscriminate dispensing, or prescribing of narcotics. In all but rare cases, they simply aren't indicated for endodontic apical microsurgery. Great care must be given to the prescription of narcotics...a patient can overdose on just one prescription!”

Post Surgical Home Care

If everything is within normal limits within the next 24 to 48 hours, sutures are removed and the patient is instructed to begin gentle cleaning of the area starting the next day (day two or three after surgery). The patient is instructed to place a washcloth over their index finger and to gently “wipe” the surgical area for a few days, as often as possible. After day five, they can begin to use their “soft-bristled brush” and begin very gentle brushing. The patient is instructed to continue the twice daily rinses of Peridex (chlorhexidine) for the next week, or so. The patient is scheduled for a follow-up visit two weeks after surgery. At the two-week visit, normally the incision is barely visible, and on occasion, cannot be detected. ***A word of caution:*** Not all patients respond to treatment as well as others. Don't be in a hurry to treat a problem that may not exist. On a few occasions, patients may be slow to respond to treatment, sometimes taking several months to heal as well as that of other patients in just weeks. If there is any doubt, or delayed healing is suspected, place the patient on antibiotics and an anti-inflammatory for a week as a precaution, but what is really desired is more time for delayed healing to occur.

Conclusion

The apical microsurgical technique described in the previous six sections has become a new standard of care in endodontic treatment and raises endodontic apical surgery to a new and exciting level. For the first time, apical surgery can be performed with predic-

table results. But, these results can only be achieved if the proper protocol is followed meticulously. The steps must be followed without compromise. If this is done, apical microsurgery can be a stress-free and predictable part of the daily regimen, for both the doctor and the newly involved dental team!

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