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Root-Canal Therapy: A Means of Treating Oral Pain and Infection

SUMMARY

What is root-canal treatment? This article shows how endodontic treatment (root-canal therapy) can preserve teeth that would otherwise be extracted, and how tooth-pulp pathology can be diagnosed. Some clinical examples illustrate how non-dental infections can masquerade as dental problems, and vice versa. (*Can Fam Physician* 1988; 34:1357–1365.)

RÉSUMÉ

Qu'est-ce que le traitement de canal? Cet article démontre comment le traitement endodontique (traitement de canal) peut contribuer à préserver des dents qui autrement nécessiteraient l'extraction et comment il est possible de diagnostiquer une pathologie de la pulpe dentaire. L'auteur présente quelques exemples cliniques pour illustrer comment certaines infections non dentaires peuvent se manifester comme des problèmes dentaires et vice versa.

Key words: endodontics, root-canal therapy, toothache

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ENDODONTICS is defined as that branch of dentistry which deals with the etiology, prevention, diagnosis, and treatment of diseases and injuries that affect the dental pulp and periapical tissues. General dental practitioners are trained in endodontic procedures, and there is also an increasing number of endodontic specialists serving most regions of Canada.

Endodontic treatment is considered to encompass pulp capping (the placement of medication in close approximation to the pulp); pulpotomy (the removal of the coronal portion of the pulp followed by placement of medication); and pulp extirpation: the treatment and preparation of root canals after removal of pulp tissue and the surgical treatment of the periapical tissues when indicated; the restoration of the natural appearance of the crown when discoloured; and the replantation of teeth that have been avulsed or luxated.

This article will deal with specific endodontic topics that directly relate to family medical practice in the diagnosis and management of oral pain and infection.

Understanding Pulpal Pathology

Although the dental pulp is a connective-tissue organ, much like other connective tissues of the body, it does display some specific characteristics. Because the dental pulp is enclosed in a solid low-compliance mineralized chamber, it cannot increase in volume during periods of vasodilation. The constituent components of the pulp (neural and vascular tissues, fibres, ground substance, interstitial fluid, odontoblasts, fibroblasts, and minor cellular components) are relatively incompressible, and so the total volume of blood within the root-canal system cannot be increased, although reciprocal volume changes can occur between arterioles and venules, the largest vascular components of the pulp. This microcirculatory system lacks a collateral system, and careful regulation of blood flow is critically important to survival of this organ.

Depending on a variety of factors, the dentin-pulp complex is an exquisitely responsive sensory system that is significant for the diagnosis of dental pain. Following tooth development the pulp retains, throughout life, its inherent potential for regeneration and repair through dentin formation.

Pulp tissue may be compromised by a variety of factors, of which bacteria and their toxic products are the most common, in the form of caries penetration through the mineralized portion of the tooth, with subsequent invasion of the pulp. Even when confined to the enamel, carious lesions will produce lymphatic infiltration in the pulp

(chronic immune response). As dentin permeability increases, these immunogens may reach the pulp. Injury to the odontoblast layer of the pulp releases enzymes, and the vascular changes of inflammation are set in motion. This initial chronic inflammatory response is believed to be either an immune complex-mediated type of hypersensitivity or a delayed type of hypersensitivity. If the carious lesion is removed and the resulting cavity restored with a protective base and dental restoration, these pulp changes may reverse, and healing may occur. However, with bacterial invasion of the pulp, neutrophils are drawn to the area; these contribute to bacterial phagocytosis and destroy pulp tissue. Soon micro-abscesses are formed, and at this point the insult is irreversible, and necrosis of the pulp will ultimately occur. Operative procedures, chemicals, and trauma may also lead to demise of the dental pulp organ by initiating an inflammatory reaction which, under certain conditions, is irreversible.

The Spread of Pulpal Pathosis to the Adnexa

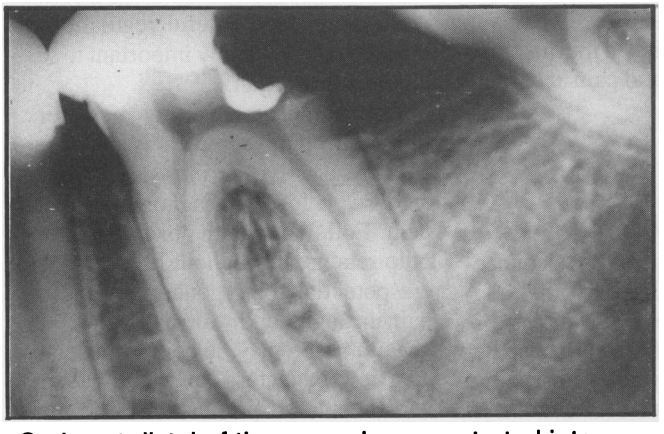
Periapical inflammation begins before the pulp is totally necrotic. Bacterial products, mediators of inflammation, and degenerating pulp-tissue products leach out from the apical foramen of the offending tooth and may initiate a chronic inflammatory response from the vessels in the periodontal ligament. The dental radiograph may show a rarefying osteitis with a periapical radiolucency (Figure 1), but viable tissue may still be present in the root canal system of the tooth in question.

As a result of the spread of pulp disease, the most common periapical disease is chronic periapical inflammation. This area of pathology will expand along a pathway of least resistance and may eventually establish drainage through a sinus tract. The patient usually complains of a "gum boil" (Figure 2) and a bad taste, and is often aware of a purulent discharge. The suppuration resulting from osseous breakdown will usually enter the oral cavity, but the endodontic literature is replete with situations where periapical abscesses have fistulated through the skin of the face. The example shown in Figure 3a highlights this problem. The patient had a chronic periapical abscess that had progressed through overlying tissues to reach the skin and discharge. This patient had several unsuccessful plastic surgical episodes to correct what was thought to be an infected sebaceous cyst. On endodontic consultation, a gutta percha tracer was placed into the sinus tract (Figure 3b), and the resulting "sinugram" (Figure 3c) indicated that the source of the infective problem was the apex of an abscessed mandibular incisor. Following non-surgical endodontic therapy there was spontaneous resolution of the draining sinus.

The chronicity of periapical lesions may also lead to Garré's osteomyelitis, a condition seen with increasing frequency in recent years. Described as a chronic, sclerosing, non-suppurative osteomyelitis with periostitis ossificans, the clinical presentation is usually similar to the case shown in Figure 4a. The clinical photograph details the hard mass formed along the lateral aspect of the body of the mandible through periosteal stripping and the laying down of pathologic bone (periostitis ossificans). The low-grade chronicity was attributed to daily ingestion of tetracyline medication for acne. The diagnostic pre-treatment radiograph (Figure 4b) shows a circumferential zone of sclerosing bone around a periapical radiolucency at the apex of the offending mandibular bicuspid. Removal of the source of infection through endodontic therapy will allow for periapical healing, as shown in the 18-month recall radiograph (Figure 4c), with the return of the normal periapical osseous architecture. Surgery is not required to correct the facial asymmetry, which may be expected to resolve over a 60–90-day period.

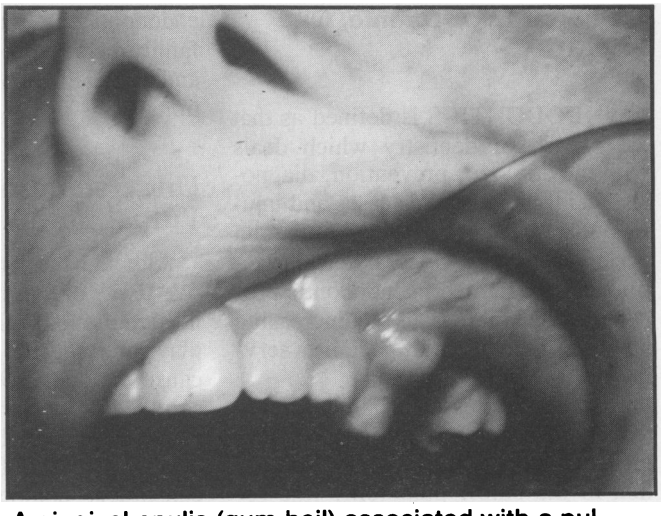
Whereas the chronic periapical reaction is most common, obviously acute inflammation may manifest as a result of the interaction between virulent offending agents and the host-resistance factor. Acute periapical inflammation creates an extremely painful situation for the patient. Before any alveolar bone resorbs, neutrophils and edema spread into the periodontal ligament space, causing pressure against nerve

Figure 1
Radiograph of Mandibular First Molar



Caries at distal of the crown has penetrated into pulp chamber causing an irreversible pulpitis. Both root apices show areas of rarefying osteitis surrounded by halos of condensing osteitis. Viable but metaplastic pulp tissue will be found in the root-canal space of this tooth.

Figure 2
A Gingival Epulis



A gingival epulis (gum boil) associated with a pulpally involved maxillary left deciduous molar. The abscess has pointed.

endings and resulting in exquisite pain. The pain will continue until sufficient bone resorption takes place to accommodate this fluid, or until adequate treatment is given. To the patient, the offending tooth will feel elevated in the socket and very tender to the touch. No lesion may be discernible on the dental radiograph.

In the event that large numbers of bacteria gain access to the periapical region, an acute apical abscess will form and subsequently spread to adjacent tissues. Clinically, swelling to various degrees will be present, accompanied by an elevated body temperature and malaise. The body will attempt to turn this situation into a chronic lesion and establish drainage through fistulation to an outer or external surface. Spread along fascial planes may result in a cellulitis and serious infections such as Ludwig's angina and cavernous sinus thrombosis, even in a healthy individual. The risk is much greater when the immune response is poor. An acute inflammatory reaction may also be superimposed on an already existing chronic periapical lesion. This acute exacerbation is termed a "phoenix abscess" (a term peculiar to endodontics), and along with the acute nature of the symptoms, the dental radiograph will show a distinct radiolucency.

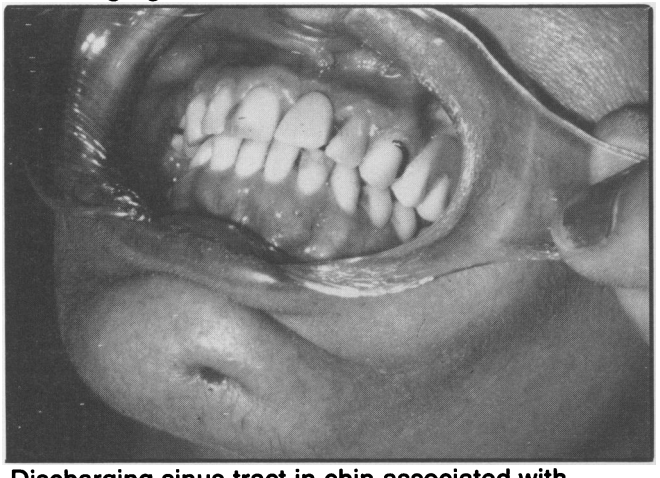
Periapical disease of non-pulpal origin may manifest as radiolucencies or radiopacities. They may be reactive (Figure 5), neoplastic, or developmental (Figure 6). Diagnosis is established by clinical, microscopic, and laboratory-value determination. Reactive lesions may include central giant-cell granulomas, the lesions of hyperparathyroidism, and periapical cemental dysplasia. All these lesions must be differentiated from periapical disease of pulpal origin.

Malignant tumours such as malignant lymphomas and metastatic carcinomas are known to invade the periapical areas of teeth. One of the key diagnostic features of these lesions is altered sensation caused by perineural invasion. These symptoms can occur for other reasons, but neoplastic disease must always be ruled out in the diagnosis. Developmental processes such as primordial cysts may also mimic periapical disease of pulpal origin. Although most radiolucencies in the periapical region are of pulpal origin, endodontic testing modalities can assist in the diagnosis of other conditions.

The Toothache: Diagnostic Considerations

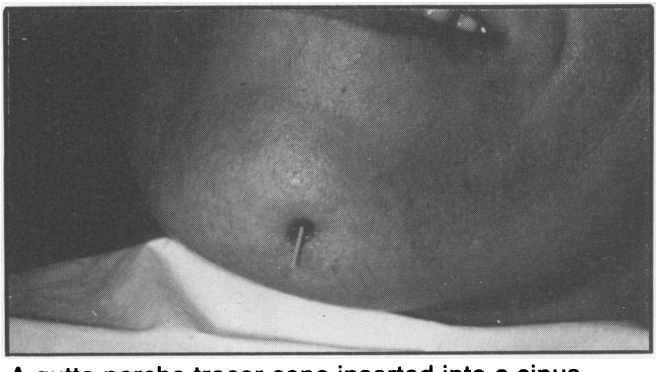
The dental pulp is a sensory organ capable of transmitting information

Figure 3a
Discharging Sinus Tract



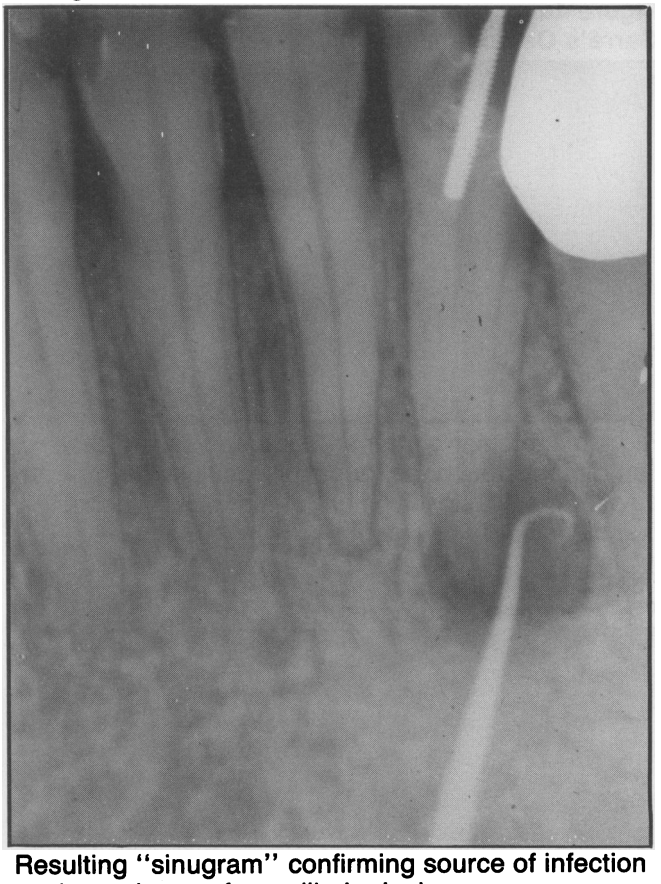
Discharging sinus tract in chin associated with pulpo-periapical disease of mandibular left lateral incisor.

Figure 3b
Gutta Percha Tracer Cone



A gutta percha tracer cone inserted into a sinus tract and gently delivered to the area of arrestment.

Figure 3c
Sinugram



Resulting "sinugram" confirming source of infection as the periapex of mandibular incisor.

from its sensory receptors to the central nervous system. Thermal change, mechanical deformation, or injury to tissues will generate afferent impulses from the pulp which will be interpreted as pain. The pulp is innervated by both afferent neurons, which conduct sensory impulses, and autonomic fibres, which provide neurogenic modulation of the microcirculation, and which may contribute to dentinogenesis. The nerve fibers of the pulp are primarily A-delta (pain, temperature, touch) and C fibers (pain and other modalities).

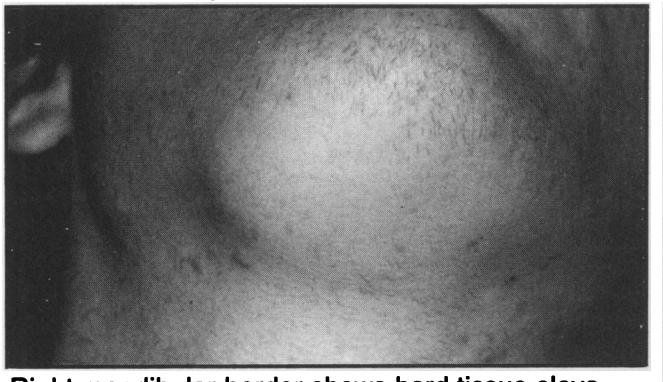
The sensory nerves to the pulp arise from the trigeminal nerve and pass into the radicular pulp in bundles *via* the apical foramen of the tooth, in close association with the arterioles and venules. The complexity of this neural network within the pulp may be expressed succinctly as an intricate plexus (of Raschkow) in the coronal pulp, with some fibres extending to the odontoblastic layer and a lesser number reaching to and into the dentinal tubules with the odontoblastic processes.

The basic event in the arousal of pain appears to be fluid movement in the dentinal tubules which may be caused by such pain-producing stimuli as heat, cold, air blasts, and probing with dental instruments that results in the deformation of the sensory nerve endings. The type of pain associated with stimulation of A-delta fibres does not necessarily signify that the pulp is inflamed, and it is incumbent on the clinician to rule out the possibility of hypersensitive dentin, cracked fillings, or dentinal fractures, before establishing a diagnosis of pulpitis.

Pulpitis may be either painless or painful, but initially pain seems to be the exception rather than the rule, although the stimulation threshold of nerve fibres is lowered by sustained inflammation. This hyperalgesia may be caused by the release of substances such as bradykinins and prostaglandins that accompany acute inflammation. Whereas pain associated with an inflamed or degenerating pulp may be either provoked or spontaneous, no one has so far been able to explain why a pulp that has been inflamed but asymptomatic for months, suddenly starts to ache in the middle of the night. Such unprovoked pain usually manifests as a dull aching, poorly localized sensation that qualitatively differs from the brief, sharp, well-localized pain associated with dentinal stimulation.

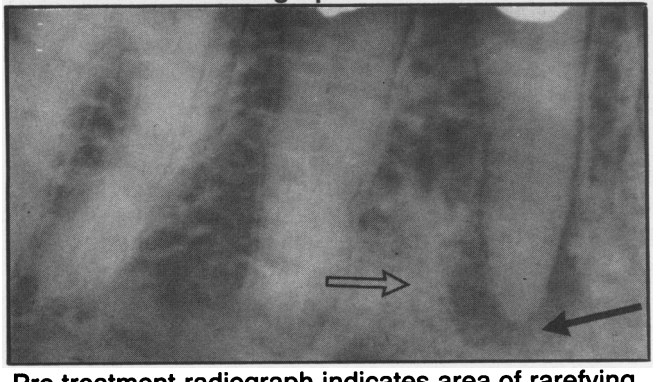
Endodontic diagnostic procedures commence, for the most obvious of reasons, with the taking of both a medical and dental history. The dental enquiry will establish inception, provoking factors, frequency, intensity, location, duration, postural factors, whether or not symptoms are stimulated or spontaneous, and whether or not the pain can be reproduced or relieved by clinical testing.

Figure 4a
Garré's Osteomyelitis



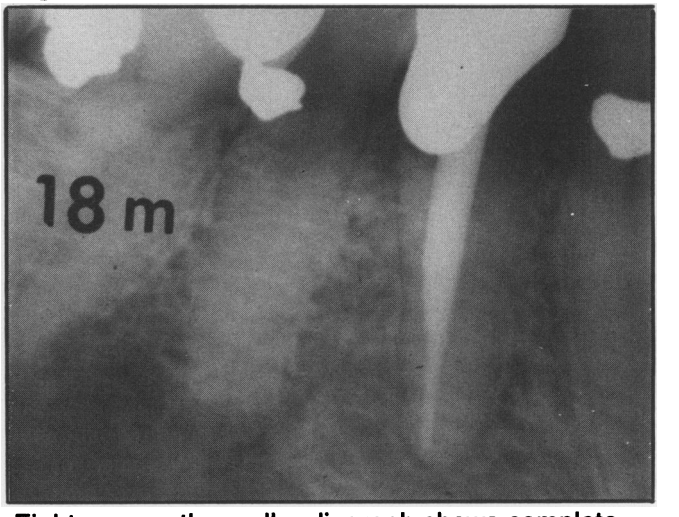
Right mandibular border shows hard-tissue elevation of periosteal bone formation resulting from pulpo-periapical involvement of mandibular right first bicuspid.

Figure 4b
Pre-Treatment Radiograph



Pre-treatment radiograph indicates area of rarefying osteitis (radiolucency) surrounded by band of sclerotic bone.

Figure 4c
Eighteen-Month Recall Radiograph



Eighteen-month recall radiograph shows complete healing of periapex following cleaning and obturation of the root-canal system. No treatment was required for the facial asymmetry, which gradually resolved over a three-month period after completion of endodontic therapy.

Following a careful external and intra-oral visual examination of the patient, a visual examination of the teeth is conducted. The dentist looks for caries, discoloured teeth, swellings, fractured or cracked teeth, and lack of translucency of the teeth. A fiberoptic light is quite useful for this examination, as it will help to pinpoint loss of natural hue and the presence of crazing or fractures of the tooth structure.

Because there is no proprioception within the confines of the dental pulp, the patient may not be able to localize the exact source of the discomfort until inflammatory edema stimulates the nerves of the periodontal ligament. A general area of pain will be described, often with the referral of this discomfort to the sensory distribution of a branch of the ipsilateral trigeminal nerve. In this situation, pain from a mandibular molar pulpitis, for example, is often referred to the ear.

Specific testing begins with palpation of the mucosa overlying the root apices, as once periapical inflammation ensues as an extension of pulpal necrosis, the overlying mucoperiosteum is quite often affected. Bimanual palpation for the presence of lymphadenopathy will often disclose the extent of the disease process.

The percussion test (application of a vertical percussive force on the occlusal surface of the tooth) will often help the clinician and patient to localize the source of pain, when it provokes a positive response from proprioceptive fibres in the periodontal ligament. The positive percussion response may indicate partial or total necrosis of the pulp, or it may be caused by other clinical factors such as a recent restoration left in hyperocclusion or a periodontal abscess. A normal percussion response may be experienced in the presence of a chronic apical periodontitis.

The extent of periodontal ligament edema may be measured by a mobility test, which indicates the degree of inflammatory change being experienced by the patient. The degree of mobility is established by lateral forces (facio-lingual) applied to the tooth in question.

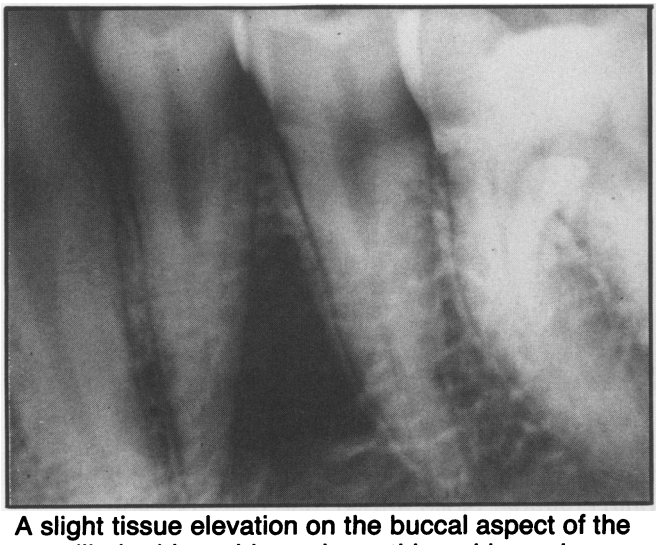
The dental periapical radiograph (Figure 7) is essential to diagnosis, and while the state of pulp health or pulp necrosis cannot be determined radiographically, the following findings should arouse suspicion of degenerative pulp changes: deep carious lesions; deep and extensive restorations; encroachment of opaque medicaments on the pulp; pulp stones; extensive canal calcification; root resorption, radiolucencies at or near the apex; root fractures; increased width of the periodontal ligament space; and periodontal disease that is radiographically evident. The clinician must be skilful in practising radiographic technique and astute in interpretation to maximize the benefits of this diagnostic tool.

One of the most common symptoms associated with a symptomatic inflamed pulp is pain induced by hot or cold stimulation. Hot and cold tests are valuable diagnostic aids because with certain types of inflamed pulps, pain may be induced or relieved by a thermal application. When several teeth in a quadrant are potential sources of concern, the patient's response to thermal tests frequently signifies to the clinician whether or not the pulp in a specific tooth is healthy or inflamed. Four reactions may be elicited by thermal testing:

- no response;
- a moderate, transient response;
- a painful response that subsides quickly after removal of the stimulus; and
- a painful response that lingers after the stimulus is removed.

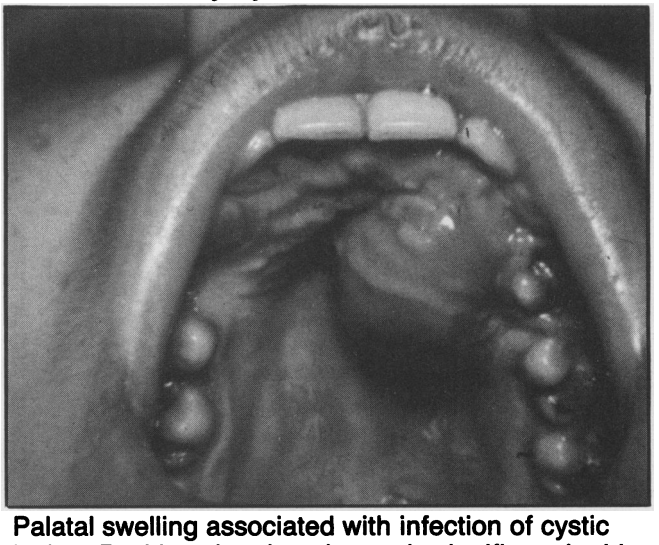
The electric pulp tester (vitality test) is designed to stimulate a response by electrical excitation of the neural elements within the pulp. This test merely

Figure 5
Giant-Cell Granuloma



A slight tissue elevation on the buccal aspect of the mandibular bicuspid causing a thinned buccal cortex, as indicated by the radiolucency noted on this radiograph, were the only significant clinical findings in this case. Histopathology of a biopsy showed immature angiomatous tissue with many giant cells present, leading to the diagnosis of a giant-cell granuloma. All teeth within this quadrant responded within normal limits to endodontic testing modalities.

Figure 6a
Globulomaxillary Cyst



Palatal swelling associated with infection of cystic lesion. Positive electric pulp test is significant in this situation, as the lesion may be developmental, forming at the junction of the globular and median processes, although currently it is believed to be a primordial cyst.

suggests whether the pulp is vital or necrotic and does not provide information as to the health or integrity of a vital pulp. Combined with other endodontic testing modalities, it directly aids the establishment of a definitive diagnosis.

Consideration should now be given to correlation of these diagnostic modalities in clinical situations from the normal pulp requiring no therapy, to the minimally involved pulp, where only palliative treatment is required to correct a reversible situation, finally arriving at irreversible pathosis that requires pulp extirpation.

A "normal" tooth is asymptomatic and displays a mild-to-moderate transient response to thermal and electric pulp stimuli; the response subsides almost immediately when such stimuli are withdrawn. The tooth and its attachment apparatus do not display a painful response when percussed or palpated. Radiographs usually disclose a clearly delineated root-canal space that tapers towards the apex; there is minimal evidence of pulp calcification, and the lamina dura is intact.

Any irritant that can affect the pulp may cause a reversible pulpitis (e.g., dental caries, periodontal manipulation of the tooth/root surface, an unlined restoration). If the cause can be removed, the pulp should revert to an uninflamed state, and symptoms should subside. A reversible pulpitis can be clinically distinguished from a symtomatic irreversible pulpitis by two methods:

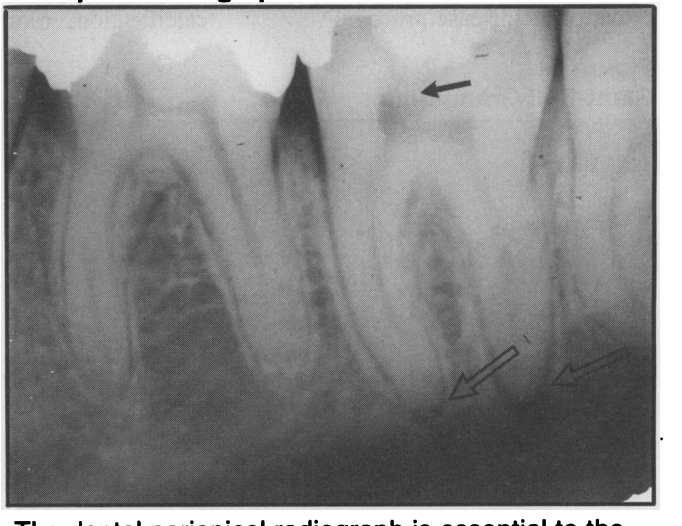
- With a reversible pulpitis there is a sharp, painful response to thermal stimulation that subsides almost immediately after the stimulus is removed. With an irreversible pulpitis there is a sharp painful response to thermal stimuli, but the pain lingers after the stimulus is removed.
- With a reversible pulpitis there is no spontaneous pain as is often found with a symptomatic irreversible pulpitis, a fact which may become evident in the dental history. Nevertheless, the diagnosis should be confirmed by thermal testing to verify the tooth/teeth involved. Treatment for a reversible pulpitis consists of placing a sedative dressing in or around the tooth to protect it. After several weeks, a properly lined permanent restoration is placed.

An irreversible pulpitis may be acute, subacute, or chronic; it may be partial or total; the pulp tissue may be sterile or infected. This condition dictates the need for endodontic treatment to eliminate the spontaneous, intermittent, or continuous paroxysms of pain. This "spontaneous" pain is usually induced by sudden temperature change, which may induce prolonged episodes of pain. There may be a prolonged painful response to cold that can be relieved by heat application, and, conversely, there may be a prolonged response to heat that can be relieved by cold application. In some situations both cold and heat may produce prolonged sensitivity. The pain experienced will be moderate to severe, depending on the severity of the inflammation, and while usually intermittent, may be fairly constant. Only in the advanced stages of an irreversible pulpitis will the radiograph be of assistance, when a thickening of the periodontal

Figure 6b
Cystic Lesion

Typical "pear"-shaped cystic lesion with displacement of root apices by cystic expansion. Diagnosis was confirmed histopathologically by the presence of respiratory epithelium lining the cystic cavity.

Figure 7
Periapical Radiograph



The dental periapical radiograph is essential to the diagnosis of pulpo-periapical disease. This mandibular second molar shows carious exposure of the pulp chamber (solid arrow), and both root apices show thickening of the periodontal ligament space, now indicating that the periapical tissues are being compromised by the egress of toxins from the root-canal space. Abnormal responses to endodontic testing modalities will confirm the diagnosis of an irreversible pulpitis with periapical extension of the disease process. These findings may be compared with the first molar which has an intact periodontal ligament space and should respond normally to endodontic testing.

ligament space may be shown. Even the electric pulp test is of limited value. Nevertheless, dental history, visual examination, and thermal testing will be the best aids in the differential diagnosis of an irreversible pulpitis.

One of the classic presentations of an irreversible pulpitis is the patient who presents carrying a bottle of cold water (or other liquid) and constantly bathing the area of the affected tooth. Obviously, in this situation, heat (even normal mouth temperature) will produce exquisite symptoms, and the immediate diagnosis of a coronal pulp abscess may be made with a degree of certainty. The pain produced here is a result of leakage of fluid from incompetent blood vessels in the pulp; cold reduces the blood flow and hence the intrapulpal pressure.

Oral Pain of Non-Dental Etiology

In the differential diagnosis of head-and-neck pain, there are many situations that mimic pain of dental origin, and of course these must be considered in the course of the diagnosis. An excellent source of this material is available.[1] An example of this type of diagnostic problem is presented in Figure 8a. The patient presented with a mid-facial cellulitis. Her chief complaint was a "tooth ache". The dental radiograph (Figure 8b) indicates a large restoration in the second bicuspid, but a normal periapex; all teeth in this quadrant responded within normal limits to all endodontic tests. A detailed history taking and visual examination of swelling above the levator angulae oris muscle insertion and crusting of the inner canthus of the eye led to diagnosis of a dacryocystitis. The patient was referred to an ophthalmologist. Dental symptoms resulted from pain referred to branches of the middle superior alveolar nerve of the maxillary division of the trigeminal nerve.

More information on oral and facial pain is available in this issue.[5]

Emergency Management of Dental Pain and Infection

Once the diagnosis is established of a degenerating (irreversible) or degenerated pulp, with or without periapical extension, the treatment alternatives are limited to endodontic therapy or extraction of the offending tooth/teeth.

The objectives of endodontic therapy are:

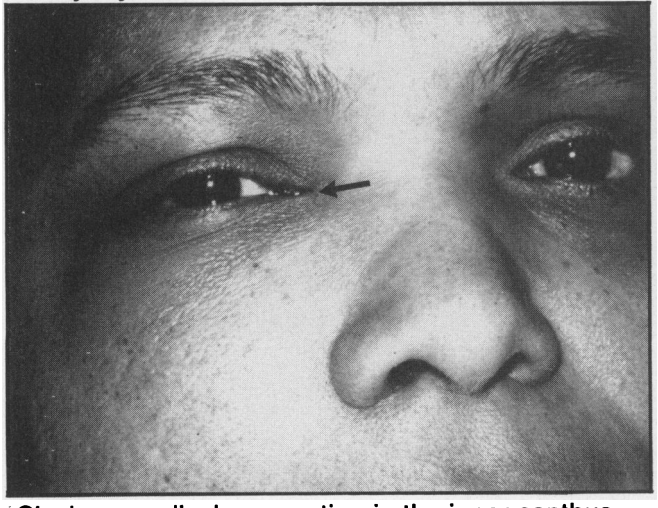
- to remove inflamed or necrotic pulp tissue, micro-organisms and their toxic products from the root-canal system; and then
- to enlarge and shape the root-canal space to receive a dense filling, in order
- to seal the root-canal space with a non-irritating material to provide a barrier between the oral cavity and the periapical tissues.

Thus, an affected tooth is rendered biologically sound: symptomless, free of any pathologic process, and functional.

The inflamed pulp tissue in the apical portion of the root-canal space must be removed at the emergency appointment. On extirpation of the pulp from an offending tooth, symptoms will usually abate quickly. Immediate relief from thermal sensitivity is obvious; however, extension of the inflammatory process to the periodontal ligament may require 24 to 48 hours to resolve. The use of moderate analgesics (acetaminophen and codeine phosphate, 300 mg., p.r.n.) and non-steroidal anti-inflammatory agents (ibuprofen, 400 mg., q.i.d.), will assist the patient during this period of discomfort. In clinical situations where the patient is febrile and showing signs of general malaise as the result of an infective process, phenoxymethyl penicillin, 300 mg., q. 6 h. for one week, may be prescribed. Usually, however, antibiotics are not required once drainage is established.

In situations where there may be intra-oral swelling, drainage will usually be attempted by the clinician through the root-canal system of the diseased tooth (Figure 9). If, as occasionally happens, the attempt is not successful, an incision for drainage in the gingival mucosa may be made, under local anesthetic, to evacuate the toxic products of inflammation and infection. In addition, a rubber T-drain may be placed or sutured into the incision to maintain the patency of the soft-tissue drainage. Through-and-through drainage has always been considered one of the most efficacious means of handling infection, and by opening through both the

Figure 8a
Dacryocystitis



Closing eye displays crusting in the inner canthus. Note that the swelling is high on the lateral aspect of the nose, superior to insertion of the levator angulae oris muscle.

Figure 8b
Periapical Radiograph

Dental periapical radiograph indicates large restoration in second bicuspid, but no obvious signs of pathology. Clinical endodontic testing modalities showed no signs of pulp disease.

tooth and the gingiva, the practitioner offers the best prognosis for rapid resolution of the pathosis. In the rare event that there is continuous sanguineous discharge from the root-canal system, it is acceptable to leave the endodontic access unsealed for 24 to 48 hours. If, however, an incision for drainage has also been established through the mucogingival tissues, it is proper to reduce contamination of the root-canal system by sealing the endodontic access.

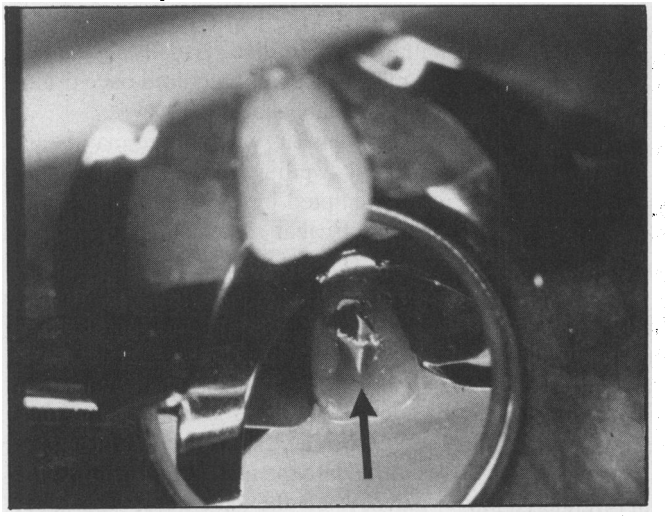
In most clinical situations of facial cellulitis of endodontic origin, where extra-oral drainage is indicated, the patient will usually be referred to an oral and maxillofacial surgeon, as this situation generally requires hospitalization for control and management of the infection. Once controlled, or as a part of the therapeutic management, endodontic therapy will usually be initiated to remove the source of the infection.

Endodontic Treatment

Teeth that would at one time have been extracted solely because of pain and pulp disease are being maintained today through endodontic treatment. The success rate for maintaining teeth is over 90%. The biologic basis of this dental specialty is constantly being enhanced through laboratory and clinical research.

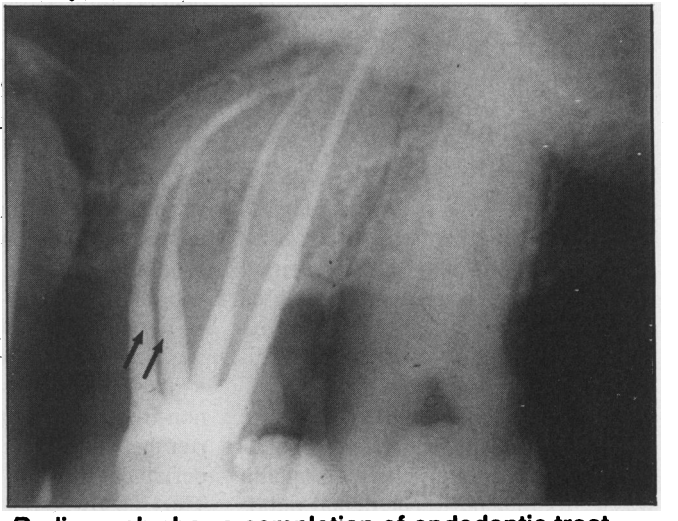
The diseased pulp is removed by the practitioner *via* an access cavity created through the occlusal or lingual surface of the tooth, using fine stainless-steel instruments in standardized graded sizes. Practitioners are trained to manage the anatomic intricacies of the teeth (Figure 10), using a variety of instrument designs, each for specific

Figure 9
Acute Periapical Abscess



Emergency endodontic access was created through the lingual of a maxillary lateral incisor that was clinically diagnosed as having an acute periapical abscess. The mirror image displays sanguineous exudate being expressed through this access. Establishing drainage *via* this route will often reduce the need for performing an incision for drainage through the soft tissues.

Figure 10
Completed Endodontic Treatment



Radiograph shows completion of endodontic treatment involving a maxillary first molar. There are four root canals, two present in the mesio-buccal root (arrows). This situation, which occurs in about 16% of the population, is an anatomic variant readily addressed by the endodontist.

functions. Various chemical agents are incorporated into the treatment regimen, referred to as the "biomechanical preparation" of the root-canal system. The resulting cleaned and tapered root-canal space is then sealed, usually with gutta percha (a rubber-like material) and a non-irritating sealing dental paste; again, a variety of materials and techniques are available. When the root-canal space has been made aseptic and sealed it off within the tooth, the periapical pathologic process will resolve through the usual modalities of hard- and soft-tissue repair and/or regeneration (Figure 11). Endodontic treatment is also carried out for pulpally involved primary (deciduous) teeth in children, as it is necessary to preserve these first teeth until they are replaced by the succeeding permanent dentition. ■

Reference

1. Seltzer S. *Pain control in dentistry.* Philadelphia/Toronto: J.B. Lippincott Company, 1978.

For Further Reading

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2. Ingle JI, Taintor JF. *Endodontics*. 3rd ed. Philadelphia: Lea & Febiger, 1985.

3. Seltzer S, Bender IB. *Dental pulp*. 2nd ed. Philadelphia/Toronto: J.B. Lippincott Company, 1975.

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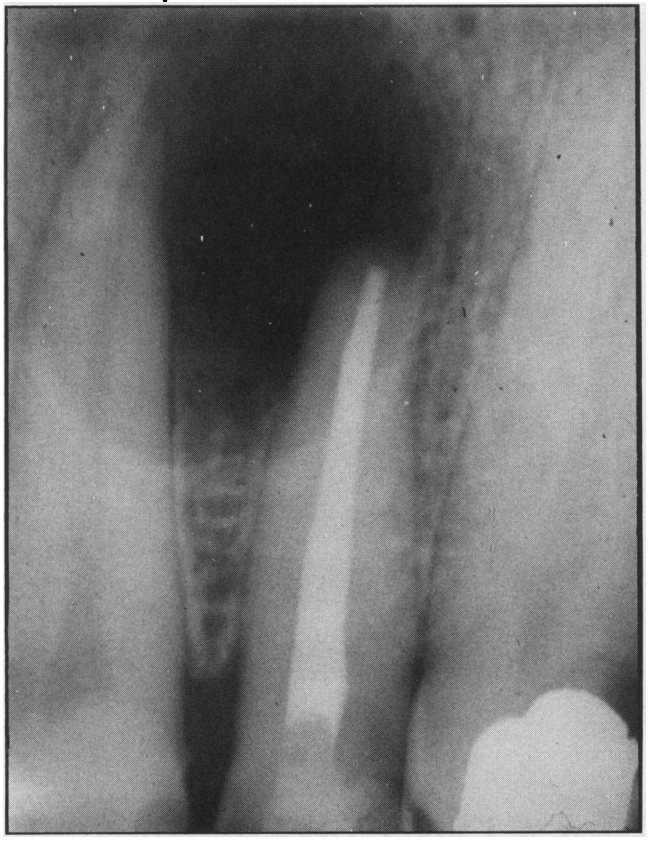
Figure 11a
Necrotic Pulp



The clinical diagnosis of a necrotic pulp with periapical extension in the form of an infected cyst that was discharging through a sinus tract in the alveolar mucosa indicated the need for endodontic therapy in this situation. The radiograph taken at the completion of treatment shows the obturated root canal space and the extent of the cystic lesion (radiolucency).

Figure 11b
Two-Year Radiograph

A two-year-recall radiograph of the treated tooth shows complete regeneration of the periapical osseous architecture.