CLINICAL ARTICLE

Thermal sensitivity of endodontically treated teeth

E. Tidwell[1], D. E. Witherspoon[1], J. L. Gutmann[1], D. L. Vreeland[2] & P. M. Sweet[3]

[1]Department of Restorative Sciences, The Texas A & M University Baylor College of Dentistry, Dallas, Texas, USA, [2]Private Practice, Manchester, Missouri, USA and [3]Millington, Tennessee, USA

Abstract

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Case reports The problem of thermal sensitivity following non-surgical root-canal treatment is explored and case reports are presented. Possible causes for post-treatment discomfort from endodontic and restorative aetiologies are discussed, as are the mechanisms to explain the patients' painful experiences. Treatment of this problem may vary from the simple replacement of a defective restoration to a more extensive non-surgical retreatment of the case, despite radiographic evidence of an acceptable root filling and normal periradicular tissues.

Keywords: diagnosis, post-treatment, retreatment, root canal therapy, thermal sensitivity.

Introduction

There are a number of criteria cited for success in root canal therapy, including radiographic evidence of periradicular healing and the absence of clinical signs and symptoms. Amongst the clinical criteria are the healing of a previously draining sinus tract, the absence of spontaneous pain, the absence of tenderness to percussion and palpation, and the absence of thermal sensitivity (Gutmann 1992).

Occasionally, a root-canal-treated tooth may exhibit thermal sensitivity, particularly to cold, at some time after completion of treatment. This may be the only clinical symptom noted by the patient. In a number of cases, this symptom will disappear when previous root canal treatment is redone if the adequacy of the root canal filling is suspect or the possibility exists of an extra canal or canals (Gutmann & Lovdahl 1997). In other cases, the problem is complicated when a particular tooth still exhibits thermal sensitivity, despite the presence of a radiographically acceptable root canal filling. Even under these circumstances, the presence of apical or coronal leakage is rather high (Kersten *et al.* 1987, Saunders & Saunders 1994).

Multiple clinical aetiologies have been suggested for post-endodontic sensitivity or pain to thermal changes (Jaeger 1994, Gutmann & Lovdahl 1997). More often than not the source is an untreated canal or another tooth. However, as will be identified in this paper, there are additional variables relative to the treatment rendered that impact on the patient's signs and symptoms (Mengel *et al.* 1992, 1993, Holland 1992, 1993, 1994).

The purposes of this article are to present a number of case histories of thermal sensitivity of root-canal-treated teeth; to discuss some of the possible sources of this sensitivity; and to formulate some recommendations, both endodontic and restorative, to eliminate or manage this problem. To support these observations and purposes, 16 cases are presented in Table 1. Some cases will be presented in greater detail. In all cases, problem-solving the source of the pain and removing the aetiology eliminated thermal sensitivity or pain.

Case reports

Case 1

The mandibular right second molar was root-canal-treated about 5 years prior to the patient reporting

Correspondence: Dr Eddy Tidwell, Assistant Professor, Department of Restorative Sciences, TAMUS Baylor College of Dentistry, 3302 Gaston Avenue, Dallas, Texas 75246, USA.

Table 1 Case reports of thermal sensitivity of endodontically treated teeth

Case no.	Tooth no.	Filling material	Symptoms	Probable cause
1	47	Silver cones mesial Gutta-percha distal	Sensitivity to cold	Silver cones extended beyond the root end/apical leakage
2	46	Silver cones	Sensitivity to cold	Distal silver cone filled flush with the root apex/apical leakage
3	26	Silver cones	Sensitivity to heat and cold	Silver cone extended beyond the apex in the mesiobuccal root/silver cones in contact with amalgam
4	11	Gutta-percha	Sensitivity to cold	Inadequate coronal restoration/coronal leakage
5	21/22	Gutta-percha Gutta-percha	Sensitivity to cold	Inadequate root canal fill/coronal and apical leakage
6	46	Gutta-percha	Sensitivity to cold	Inadequate root canal fill/apical leakage
7	46	Silver cones	Sensitivity to cold	Silver cones flush with the apex/apical leakage
8	12	Silver cones	Sensitivity to cold	Inadequate root canal fill/apical leakage
9	25	Gutta-percha	Sensitivity to cold	Inadequate root canal fill/apical leakage
10	46	Gutta-percha with metallic core carrier	Intense pain to cold	Metallic core carriers in contact with amalgam restoration/ case treated 1 week prior
11	26	Gutta-percha with mettalic core carrier	Pain to cold	Metallic core carrier short in the mesiobuccal canal and the presence of a mesiopalatal canal
12	25	Gutta-percha with metallic core carrier	Pain to cold	Metallic core carrier extending from the occlusal surface to the periradicular tissues
13	46	Silver cones	Pain to cold	Silver cones beyond the root end/corrosion leakage/cones in contact with gold onlay
14	22	Broken instrument	Pain to heat and cold	Broken instrument beyond apex and in contact with post
15	47	Gutta-percha with metallic core carriers	Pain to cold	Four metallic gutta-percha core carriers short of ideal location for canal obturation/tissue present in canals
16	27	Gutta-percha	Pain to cold	Presence of a mesiopalatal canal

an increasing sensitivity to cold from that tooth. No other clinical signs or symptoms were present. A periradicular radiograph showed a well-compacted gutta-percha filling in the distal canal and overextended silver cones in the mesial canals (Fig. 1a). The silver cones also appeared to contact the silver amalgam coronal restoration. This was corroborated clinically during retreatment. The silver cones were easily removed from the mesial canals and corrosion was noted on the apical third of both cones. New working lengths were established and the mesial canals were recleaned, shaped and obturated with laterally compacted cold gutta-percha and Grossman's sealer. No second distal canal was detected. Whilst it is recognized that some practitioners would have retreated the distal canal as well, in this case the single distal canal filling appeared acceptable and therefore was not revised. A thin layer of gutta-percha was placed on the floor of the pulp chamber and the remaining pulp chamber filled with a non-acid etched, composite resin. The coronal access was coated with a cavity varnish and sealed with a burnished silver amalgam (Fig. 1b). The patient reported that the cold sensitivity disappeared immediately after treatment.

Case 2

The maxillary left first molar was root-canal-treated with silver cones and the distobuccal root had been resected. The tooth was symptom-free for 5 years, when the patient noted thermal sensitivity to both heat and cold. No other clinical signs or symptoms were present. Radiographic examination revealed the mesiobuccal and palatal canals filled with silver cones that appeared to be in direct contact with the silver amalgam (Fig. 2a). There was a slight thickening of the periodontal membrane space at the palatal root apex. The mesiobuccal silver cone extended beyond the apex. Upon removal, the palatal silver cone exhibited no corrosion, whilst the mesiobuccal cone was corroded in the apical third. The mesiobuccal and palatal canals were recleaned, shaped and filled with laterally compacted cold gutta-percha and Grossman's sealer (Fig. 2b). No second mesiobuccal canal was detected. The patient reported no further sensitivity to heat or cold.

Discussion

When a tooth retains or develops thermal sensitivity after completion of root canal treatment, the clinician

Figure 1 (a) Mandibular right second molar with silver cones beyond the end of the root. Cones are also in contact with occlusal amalgam (case 2, Table 1). (b) Mesial canals retreated within confines of the root.

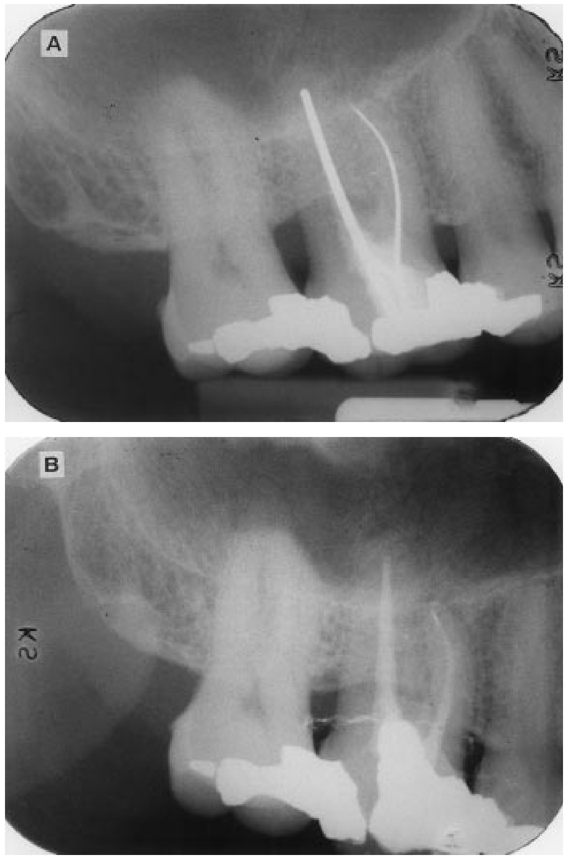

Figure 2 (a) Maxillary right first molar following distobuccal root resection (case 4, Table 1). Silver cones in the mesiobuccal and palatal canals. (b) Retreatment of the canals.

should proceed in a logical manner to determine the cause. Reproduction of the patient's chief complaint is a significant step in diagnosis (Keir *et al.* 1991, Gutmann & Lovdahl 1997). Table 2 lists some of the possible causes for this sensitivity. A given case may present any combination of these causes, but the first step should be to assess the quality of the previous root canal treatment. Whilst limited to a two-dimensional radiographic evaluation, the canals should be assessed for shape and thoroughness of obturation. The determination of canal cleanliness is impossible on a radiograph. What is the nature of the filling material gutta-percha, silver cones or paste? Does the material appear well compacted or are there voids? Is the filling grossly short or is it extended beyond the apex, regardless of the nature of the material? Is the filling material a combination of gutta-percha and metallic core carrier? If so, the core may have been stripped of its gutta-percha and the metallic portion may be in contact with inflamed tissues or tissue fluids either in the canal or beyond the root end (Fig. 3a). Likewise,

Table 2 Possible causes of thermal sensitivity of root-canal-treated teeth

- Inadequate cleaning, shaping and canal obturation
- Presence of extra, undetected canal or canals
- Silver cones in direct contact with the coronal restoration/periradicular tissues
- Metallic gutta-percha core carriers in contact with oral/pulpal/periradicular tissues
- Broken metallic instrument in contact apically with vital tissue
- Defective coronal restorations
- Referred pain from another pulpally inflamed tooth
- Other unknown source

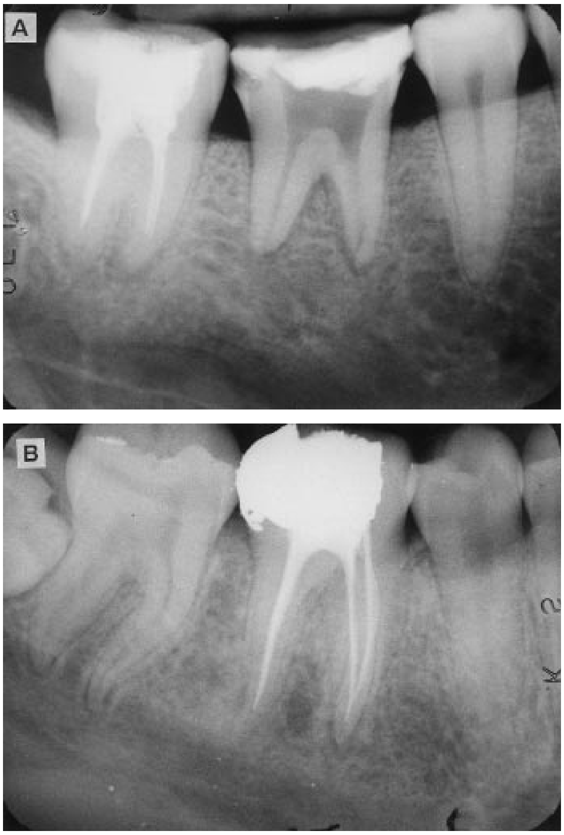

Figure 3 (a) Mandibular right second molar with four metallic core gutta-percha carriers short of the ideal length (case 16, Table 1). Canal space was not clean and the patient complained of pain to cold stimulation. (b) Mandibular right first molar with three metallic core gutta-percha carriers in contact with the coronal amalgam restoration (case 11, Table 1). Patient was experiencing intense pain in response to cold.

these metallic cores may be in contact with the metallic coronal restoration (Fig. 3b) (Gutmann & Battrum 1994).

Even if the previous root canal filling appears adequate, the clinician should still examine the case for possible undetected extra canals (Green 1973). Radiographs at different horizontal angulations often reveal their presence. If there is any indication of an extra canal, the tooth should be re-accessed and the pulpal floor carefully re-examined. In these cases, evaluation under magnification may be beneficial.

Even though extra canals may not be present clinically, the diagnostic reliability of the buccal radiograph to determine the quality of the apical or coronal obturation is questionable. When the radiographic appearance of the root filling is unacceptable, the likelihood of leakage is high. However, even when the root filling is radiographically acceptable, the likelihood of leakage is still rather high (Kersten *et al.* 1987). Because of our willingness to accept unquestioningly a good radiographic appearance, cognitive dissonance oftens obscures our vision regarding other possible causes of problems (Seltzer & Bender 1965). In this situation cognitive dissonance is characterized as having important information that supports a particular position or state of existence (even good radiographs do not provide an accurate assessment of the quality of the root canal treatment or the presence or absence of an apical seal), yet as practitioners we make choices that may be in direct opposition to the facts (i.e. we are willing to accept the radiographic findings as definitive information regarding the biological status of the tooth in question).

Clinically, thermal testing is the only means to identify the source of the symptoms. It is evident that the object of the testing should be to reproduce the symptoms described by the patient. If cold sensitivity is the complaint, test with ice or a refrigerant spray. If heat is the complaint, hot temporary gutta-percha stopping or a controlled heating device is effective for testing. It is important to recall at the outset which teeth might have additional canals and where they might be located. Begin testing on presumably normal teeth in the quadrant, to establish a basis for comparison. Choose unrestored, non-carious teeth if possible. It is easy and helpful to test each tooth in the quadrant successively from anterior to posterior, if the complaint seems to be located posteriorly. If it is an anterior tooth, begin testing three or four teeth on one side of the suspected location and continue to three or four teeth on the opposite side. Contralateral teeth are also tested as controls, with previously root-canal-treated teeth, if present, also serving as a controls. During the testing, try to place the stimulus in the same position on each tooth, with the buccocervical areas usually the most responsive. On presumably normal teeth, one normal response will be sufficient. On heavily restored teeth, carious teeth or suspected teeth, it is wise to test multiple surfaces of the same tooth before progressing to the next tooth. Test directly on large metallic intracoronal restorations last. Full crowns should also be tested on all exposed surfaces. Since some thermal responses are delayed, it is also wise to test slowly and give each tooth time to respond to each test. No special consideration should be given

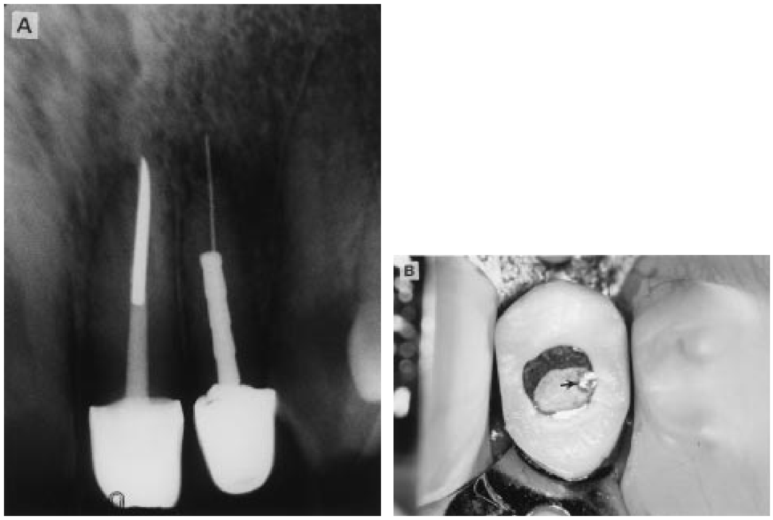

Figure 4 (a) Extension of a broken file beyond the root apex in a maxillary lateral incisor (case 15, Table 1). Instrument is in contact with the post and crown. Patient was experiencing pain in response to both hot and cold and was told by the referring dentist that 'it was impossible to experience thermal pain with a root-treated tooth'. (b) Extension of a metallic core carrier to the coronal surface (arrow) of the maxillary premolar (case 13, Table 1). Patient was experiencing pain in response to cold and biting.

to the root-canal-treated tooth. If isolation is a problem, a rubber dam can be easily placed and moved from tooth to tooth. A response to thermal testing on the root-canal-treated tooth should be repeated. If the response is immediate and duplicates the patient's symptoms, it would indicate the presence of tissue within the canal system. Because of the frequent presence of large restoration contacts, thermal testing on one tooth may elicit a delayed response on an adjacent tooth. Usually when the second tooth is tested directly, the abnormal response will be much more obvious and immediate. Knowledge of canal anatomy should give a clue as to the location of an untreated canal. In maxillary molars, for example, it is usually the second mesial canal in the mesiobuccal root (mesiopalatal), and in mandibular molars, it is usually a second canal in the distal root. In mandibular incisors and premolars, it is a second canal located lingual to the main canal. These canals are usually not visible on a radiograph. The treatment of choice is to find and treat or retreat this canal in essence removing the aetiology.

A second possibility indicated for a painful thermal response is a tooth in the quadrant other than the root-canal-treated tooth. A proper endodontic diagnostic regimen will determine this and treatment will be straightforward. Pain or other symptoms, including thermal sensitivity, referred from another pulpally involved tooth should always be considered in a differential diagnosis (Gutmann & Lovdahl 1997) as well as pain from other sources, such as the maxillary sinuses or paranasal pain (Jaeger 1994). In the latter situation, pain and cold sensitivity may be referred from the maxillary sinus and nasal mucosa to specific teeth. When this occurs, usually groups of teeth are hypersensitive to cold and tender to percussion on the affected side, and there may be spontaneous, mild pain (Jaeger 1994). This does not rule out, however, maxillary sinus pain being referred to only one tooth.

Habit reference pain is pain referred from one tooth to another or from the paranasal tissue into the teeth. Habit reference pain is a learned phenomenon and is supported in clinical observations where a pain may be referred not to its usual point of reference but to a site of a previous surgical operation, trauma or localized pathological process. The concept of habit reference was verified by Hutchins & Reynolds (1947). Traumatized sensory nerves of compromised dental pulps were viewed as a learned response and could explain how pain in one tooth could be referred there from pulpitis in another tooth some distance away, even in the opposing arch.

The third clinical possibility is the presence of metallic objects, such as silver cones, broken instruments, metallic carriers and so forth, that are in contact simultaneously with the oral and periradicular environment (Fig. 4). A fourth clinical possibility may be an electrical current that is set up in the presence of corrosion of metallic restorations involved in coronal leakage and that communicates to the periradicular tissues.

The cases discussed primarily involved overextended silver cones and to some degree contact of the silver cones with metal coronal restorations. Removing the cones and retreating the canals with laterally compacted gutta-percha and Grossman's sealer resolved the thermal sensitivity. In these cases and others, the thermal sensitivity may have been due in part to periapical percolation and irritation from the oxidation by-products from the corroded silver cones (Fig. 5) (Seltzer *et al.* 1972). It can also be conjectured that the thermal sensitivity was exacerbated by thermal transference via the coronal restorations in direct contact with the silver cones (Williams & Cunningham 1979). This phenomenon is also noted with coronally extended metallic gutta-percha core carriers (Figs 3b and 6) (Gutmann & Battrum 1994).

Since the 1930s much has been written regarding the merits of silver cones vs. gutta-percha in root canal filling materials. It is not the purpose of this article to debate this issue, but overextended silver cones would appear to dispose to a predictable failure due to their contact with the periradicular tissues or oral fluids (Fig. 6) (Seltzer *et al.* 1972, Goldberg 1981).

All reported cases revealed an immediate response to thermal testing. There was no delayed reaction to thermal stimulation as suggested by Michailesco *et al.* (1995). Since varying degrees of chronic inflammation are highly probable in all the cases (Brynolf 1978, 1979, Pascon *et al.* 1991, Holland 1992), and increased levels of innervation are associated with regions of chronically inflamed tissues (Martinelli & Rulli 1967, Kimberly & Byers 1988, Holland 1992), it is conceivable that this could account for the immediate response to thermal stimulation.

Any post-treatment evaluation of root-canal-treated teeth should include questioning the patient about thermal sensitivity. Thermal sensitivity may be present and patients may not remember it until the attending clinician brings it to their attention. Clinical experience suggests that thermal sensitivity near the attached gingiva may be attributable to coronal leakage or thermal transfer from a restoration to the adjacent tissue. If patients state that they feel the thermal sensitivity deeper in the tissues towards the apex of the root, apical leakage should be considered.

A smaller number of cases may still exhibit thermal sensitivity despite the clinician having ruled out all of the factors in Table 2. In these cases, it may be prudent to consider retreatment even through the radiograph may reveal an adequate root canal filling. Although radiographic evidence of periradicular healing is an important criteria for endodontic success, there are some limitations to the radiograph alone in evaluating endodontic success or failure (Bender & Seltzer 1961a,b, Goldman 1972, Kersten *et al.* 1987). Furthermore, inflammation may persist or recur at varying periods of time after the completion of root canal treatment despite radiographic evidence suggesting successful repair (Brynolf 1967, 1978, 1979, Seltzer 1988). Therefore, in some cases, periradicular lesions may not completely resolve despite excellent root canal treatment and apparent radiographic evidence of technical success. Consequently, retreatment must be considered to resolve thermal sensitivity.

What requires explanation in these cases in which a nerve (or nerves) is being stimulated thermally, particularly in those cases where all canals have been obturated to a degree of clinical acceptability? A clue provided by all patients in these reported cases is that every patient could point to the offending tooth when the chief complaint was reproduced. Accurate localization of the offending tooth suggests proprioceptive stimulation.

In vivo studies have shown that the periodontal ligament is innervated by thick and thin myelinated fibers as well as unmyelinated fibres (Mengel *et al.* 1993). Electrophysiological *in vivo* investigations demonstrated that the thick myelinated A-δ fibers were mechanicoreceptors. The unmyelinated C fibres were shown to be polymodal nociceptors (Mengel *et al.* 1992). It was demonstrated that A-δ fibers could be activated by heat and/or cold and/or chemical stimulation (Mengel *et al.* 1992, 1993).

In vivo studies have also revealed that the response characteristics of periodontal A-δ fibers and

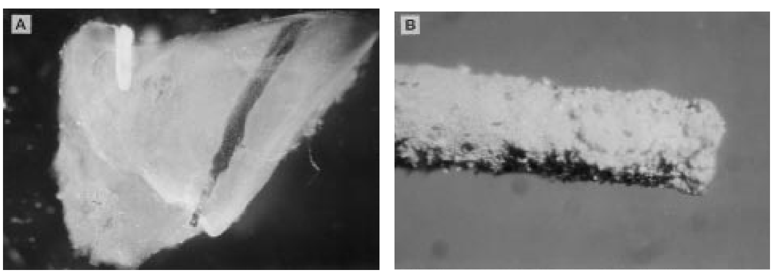

Figure 5 (a) Cleared apical root segment with retained corroded silver cone. Note the irregularity, lack of adaptation and presence of corrosion products. (b) Close-up photo of the corrosive nature of the cone at the apex.

Figure 6 The arrows indicate the position of metallic core carriers that were in contact with the metallic crown. This caused significant pain in response to cold stimulation.

periodontal C fibres seem to be similar to those of the pulpal A-δ fibres and pulpal C fibres (Jyväsjärvi & Kniffkik 1989, Mengel *et al.* 1993). The high threshold to mechanical stimulation of the periodontal C fibres suggests that they might play a role in periodontal nociception (Mengel *et al.* 1992). The A-δ fibres respond to heat and cold (Mengel *et al.* 1992) and produce nociceptive responses that are interpreted by the brain as pain.

It is highly probable that all of the teeth listed in Table 1 were associated with varying degrees of chronic inflammation (Brynolf 1978, 1979, Pascon *et al.* 1991, Holland 1992) Furthermore, it is well established that periradicular regions of chronic inflammation are associated with increased levels of innervation (Martinelli & Rulli 1967, Holland 1992) and sprouting of nerve fibers (Khayat *et al.* 1988, Byers *et al.* 1990). Therefore, there appears to be an interaction between inflammation and changes in neural tissues in the periradicular tissues (Kimberly & Byers 1988). Studies have also shown that there is a proliferation of nerves beneath the apices of root-canal-treated teeth. The density of innervation in the periapical region of teeth obturated with gutta-percha and Grossman's sealer and clinically successful was statistically significant when compared with untreated controls (Holland 1992, 1993). Upon activating these fibres, mediators such as histamine, substance P (SP) and calcitonin gene-related peptides are released from the peripheral terminals of afferent nerves, causing further neurogenic inflammation (Gyorfi *et al.* 1992). The initial induction of the inflammatory process in these cases may occur after the endodontic procedure, resulting from the irritant nature of the materials used to fill the root canal and/or incomplete root canal cleaning and shaping (Holland 1994). The net result of this interaction is continued stimulation of the periradicular region with a subsequent higher than normal density of neural elements and a decrease in activation thresholds (Cadden *et al.* 1983, Närhi *et al.* 1992). The possibility also exists that in some cases the endodontic treatment may result in the formation of local periapical neuromas, resulting in site-altered nervous activity that may, in some circumstances, be involved in the initiation of the pain (Holland 1988).

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