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## REVIEW

# Microbial causes of endodontic flare-ups

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### Abstract

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**Literature review** Inter-appointment flare-up is characterized by the development of pain, swelling or both, following endodontic intervention. The causative factors of flare-ups encompass mechanical, chemical and/or microbial injury to the pulp or periradicular tissues. Of these factors, microorganisms are arguably the major causative agents of flare-ups. Even though the host is usually unable to eliminate the root canal infection, mobilization and further concentration of defence components at the periradicular tissues impede spreading of infection, and a balance between microbial aggression and host defences is commonly achieved. There are some situations during endodontic therapy in which such a balance may be disrupted in favour of microbial aggression, and an acute periradicular inflammation can ensue. Situations include apical extrusion of infected debris, changes in the root canal microbiota and/or in environmental conditions caused by incom-

plete chemo-mechanical preparation, secondary intraradicular infections and perhaps the increase in the oxidation–reduction potential within the root canal favouring the overgrowth of the facultative bacteria. Based on these situations, preventive measures against infective flare-ups are proposed, including selection of instrumentation techniques that extrude lesser amounts of debris apically; completion of the chemo-mechanical procedures in a single visit; use of an antimicrobial intracanal medicament between appointments in the treatment of infected cases; not leaving teeth open for drainage and maintenance of the aseptic chain throughout endodontic treatment. Knowledge about the microbial causes of flare-ups and adoption of appropriate preventive measures can significantly reduce the incidence of this highly distressing and undesirable clinical phenomenon.

**Keywords:** endodontic treatment, flare-up, root canal infection.

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### Introduction

The inter-appointment flare-up is a true complication characterized by the development of pain, swelling or both, which commences within a few hours or days after root canal procedures and is of sufficient severity to require an unscheduled visit for emergency treatment.

Occurrence of mild postoperative pain is relatively common even when the treatment has followed acceptable standards, and this should be expected and anticipated by patients. However, an inter-appointment flare-up has been demonstrated to be an unusual occurrence.

Studies have reported varying frequencies of flare-ups, ranging from 1.4 to 16% (Morse *et al.* 1986, Torabinejad *et al.* 1988, Barnett & Tronstad 1989, Trope 1990, Walton & Fouad 1992, Harrington & Natkin 1992, Imura & Zuolo 1995, Siqueira *et al.* 2002a). Certain factors significantly influence the development of inter-appointment flare-ups, including age, gender, tooth type, pulpal status, presence of preoperative pain, allergies and presence of a sinus tract stoma (Morse *et al.* 1986, Torabinejad *et al.* 1988, Walton & Fouad 1992, Imura & Zuolo 1995, Siqueira *et al.* 2002a).

The causative factors of inter-appointment flare-ups comprise mechanical, chemical and/or microbial injury to the pulp or periradicular tissues (Seltzer & Naidorf 1985, Torabinejad *et al.* 1988). Indeed, most cases of flare-up occur as a result of acute periradicular inflammation

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(acute apical periodontitis or acute periradicular abscess), secondary to intracanal procedures. Acute periradicular inflammation can develop as a result of any type of insult from the root canal system. Regardless of the type of injury, the intensity of the inflammatory response is directly proportional to the intensity of the tissue injury (Siqueira 1997, Trowbridge & Emling 1997). Following injury to the periradicular tissues, a myriad of chemical substances are released or activated which will mediate characteristic events of inflammation, such as vasodilation, increase in vascular permeability and chemotaxis of inflammatory cells. The chemical mediators of inflammation include vasoactive amines, prostaglandins, leukotrienes, cytokines, neuropeptides, lysosomal enzymes, nitric oxide, oxygen-derived free radicals and plasma-derived factors (complement, kinin and clotting systems; Cotran *et al.* 1999). Synthesis and/or release of practically all of these mediators have been reported to occur in periradicular lesions (for review see Torabinejad 1994, Nair 1997). Although some mediators can cause pain through direct stimulation of sensory nerve fibres, the major inflammatory event responsible for periradicular pain appears to be the increase in vascular permeability, resulting in exudation and oedema formation (Siqueira 1997, Trowbridge & Emling 1997). These phenomena induce an increase in tissue hydrostatic pressure with consequent compression of nerve endings and pain generation, provided pressure is sufficiently high to reach the excitability threshold of periodontal nerve fibres.

Mechanical and chemical injuries are often associated with iatrogenic factors. Examples of mechanical irritation causing periradicular inflammation include instrumentation (mainly overinstrumentation) and overextended filling materials. Examples of chemical irritation include irrigants, intracanal medications and overextended filling materials. However, microbial injury caused by microorganisms and their products that egress from the root canal system to the periradicular tissues is conceivably the major and the most common cause of inter-appointment flare-ups (Bartels *et al.* 1968, Seltzer & Naidorf 1985). The frequency of flare-ups has been reported to be significantly higher in necrotic pulp cases (presumably infected) than in vital pulp cases (presumably uninfected) (Walton & Fouad 1992). Microbial insult is also often coupled with iatrogenic factors to cause flare-ups. Yet, a flare-up of infectious origin can sometimes occur even though root canal procedures have been performed judiciously and carefully. This review focuses on the surmised mechanisms by which microorganisms can cause inter-appointment flare-ups.

## Symptomatic endodontic infections

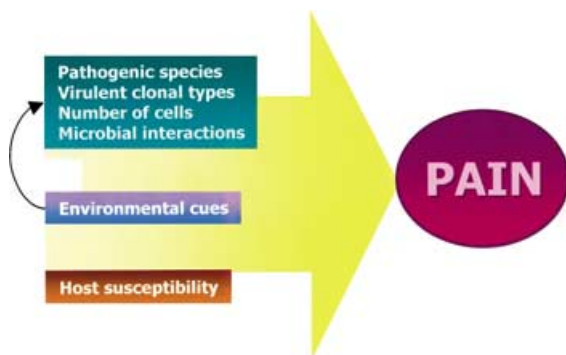
A large body of evidence indicates that periradicular inflammatory disorders are infectious diseases caused by microorganisms infecting the root canal system (Kakehashi *et al.* 1965, Sundqvist 1976). Environmental conditions within the root canal system containing necrotic pulp tissue are conducive to the establishment of several different oral bacterial species, particularly strictly anaerobic bacteria with demanding nutritional requirements (Sundqvist 1992). It has been suggested that the presence of certain bacterial species is associated more with some clinical features of periradicular diseases. *Porphyromonas* species have been found to be associated with symptomatic periradicular lesions including abscessed teeth (Sundqvist 1976, van Winkelhoff *et al.* 1985, Haapasalo *et al.* 1986, Siqueira *et al.* 2001a). Yoshida *et al.* (1987) frequently isolated *Prevotella* species and *Finegoldia* (formerly *Peptostreptococcus*) *magna* from cases showing acute clinical symptoms. Hashioka *et al.* (1992) observed that cases having percussion pain frequently displayed *Peptostreptococcus* species, *Eubacterium* species, *Porphyromonas endodontalis*, *P. gingivalis* and *Prevotella* species. Gomes *et al.* (1996) reported that *Prevotella* species and/or *P. micros* were significantly associated with pain. *Prevotella* species were also the most commonly recovered bacteria from cases with tenderness to percussion. Using molecular genetic methods, some putative oral pathogens, such as *Treponema denticola*, *Tannerella forsythensis* (previously *Bacteroides forsythus*) and *Dialister pneumosintes* have been detected in high prevalence values in symptomatic endodontic infections, including cases of acute periradicular abscesses (Siqueira *et al.* 2000c,d, Rôças *et al.* 2001, Siqueira *et al.* 2001b,c, Rôças & Siqueira 2002).

All these reports generated a great deal of evidence that some Gram-negative anaerobic bacteria were closely associated with the aetiology of symptomatic periradicular lesions, including cases of acute periradicular abscess. Nevertheless, studies have revealed that certain species commonly found associated with symptoms may also be frequently observed in asymptomatic cases (Haapasalo *et al.* 1986, Baumgartner *et al.* 1999, Siqueira *et al.* 2000c,d, 2001a). The following hypotheses can help to explain these findings (Siqueira 2002):

- It is well known that all the clonal types of a pathogenic species are not equally virulent (Finlay & Falkow 1997, Özmeriç *et al.* 2000). The fact that strains of presumed endodontic pathogens differ in virulence can be one of the explanations why some species are found in both symptomatic and asymptomatic cases. Thus, one

may surmise that cells of a given microbial species present in the symptomatic cases are of more virulent clonal types than those found in asymptomatic cases.

- The presence of other species in a mixed community acting through synergic or additive interactions can also influence virulence, as most of the putative endodontic pathogens only show virulence or are more virulent when in mixed cultures (Sundqvist *et al.* 1979, Baumgartner *et al.* 1992, Kesavalu *et al.* 1998, Siqueira *et al.* 1998b, Yoneda *et al.* 2001).
- The pathogen must achieve sufficient numbers to initiate and/or to maintain a disease (microbial load). Thus, the difference in numbers may also explain why some species are found in both symptomatic and asymptomatic cases. It is possible that the cells of a given species are in higher numbers in symptomatic cases than in the asymptomatic ones.
- Virulent strains of pathogenic species do not always express their virulence factors. Recent evidence indicates that bacteria can change their behaviour and hence become virulent or even more virulent because of environmental stresses generated by conditions such as starvation, populational density, pH, temperature, iron availability and so on (Finlay & Falkow 1997, Kolenbrander 1998, Kesavalu *et al.* 1999, Kievit & Iglewski 2000, Lazazzera 2000).
- Differences in host susceptibility to various infectious agents have been recognized for several years, and periradicular diseases are certainly influenced by this factor (Mims *et al.* 2001, Siqueira 2002). Hypothetically, the subjects that had reduced ability to cope with infections may be more prone to present clinical symptoms associated with endodontic infections.



**Figure 1** Factors influencing the development of pain associated with endodontic infections. In addition to the pathogenic species, other microbial and host-related factors are also highly likely to be involved in the pathogenesis of symptomatic periradicular diseases (see text for more discussion).

It can be assumed that in addition to the presence of certain potentially pathogenic species, a multitude of other factors are involved in the aetiology of symptomatic endodontic infections (Fig. 1).

### Microorganisms as causative agents of flare-ups

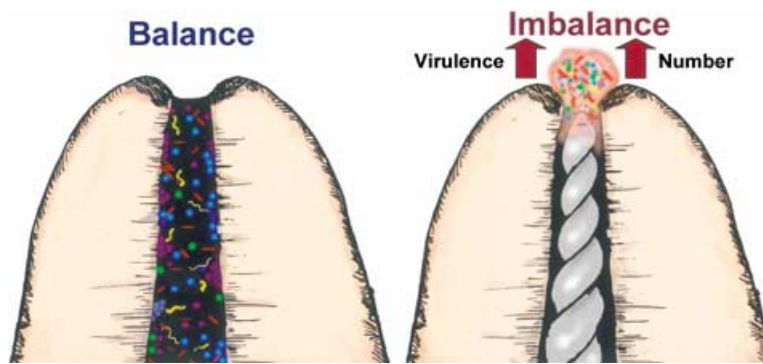
Microorganisms are the major causative agents of acute periradicular inflammation, regardless of whether it develops preoperatively or postoperatively. There are some special circumstances in which microorganisms can cause flare-ups. The following discussion concerns these specific situations.

#### Apical extrusion of infected debris

Apical extrusion of infected debris to the periradicular tissues is possibly one of the principal causes of postoperative pain (Wittgow & Sabiston 1975, Seltzer & Naidorf 1985, Siqueira 1997). In asymptomatic chronic periradicular lesions associated with infected teeth, there is a balance between microbial aggression (from the infecting endodontic microbiota) and host defence in the periradicular tissues. During chemo-mechanical preparation, if the microorganisms are apically extruded, the host will face a situation in which it will be challenged by a larger number of irritants than it was before. Consequently, there will be a transient disruption in the balance between aggression and defence in such a way that the host will mobilize an acute inflammation to re-establish the equilibrium (Fig. 2).

Iatrogenic overinstrumentation promotes the enlargement of the apical foramen, which may permit an increased influx of exudate and blood into the root canal (Chávez de Paz Villanueva 2002). This will enhance the nutrient supply to the remaining bacteria within the root canal that can then proliferate and cause exacerbation of a chronic periradicular lesion. Although this possibility exists, exacerbations as a result of overinstrumentation are more likely to develop as a result of mechanical injury to the periradicular tissues (the larger the files, the larger the tissue damage), which is usually coupled with apical extrusion of a significant amount of infected debris.

Forcing microorganisms and their products into the periradicular tissues can generate an acute inflammatory response, whose intensity will depend on the number and/or virulence of the extruded microorganisms. In other words, quantitative (microbial numbers) and/or qualitative (microbial species) factors will be decisive



**Figure 2** Apical extrusion of microorganisms and/or their products during chemo-mechanical procedures may induce acute periradicular inflammation to re-establish the balance between aggression and defence. Such response depends on both the number and virulence of extruded microorganisms.

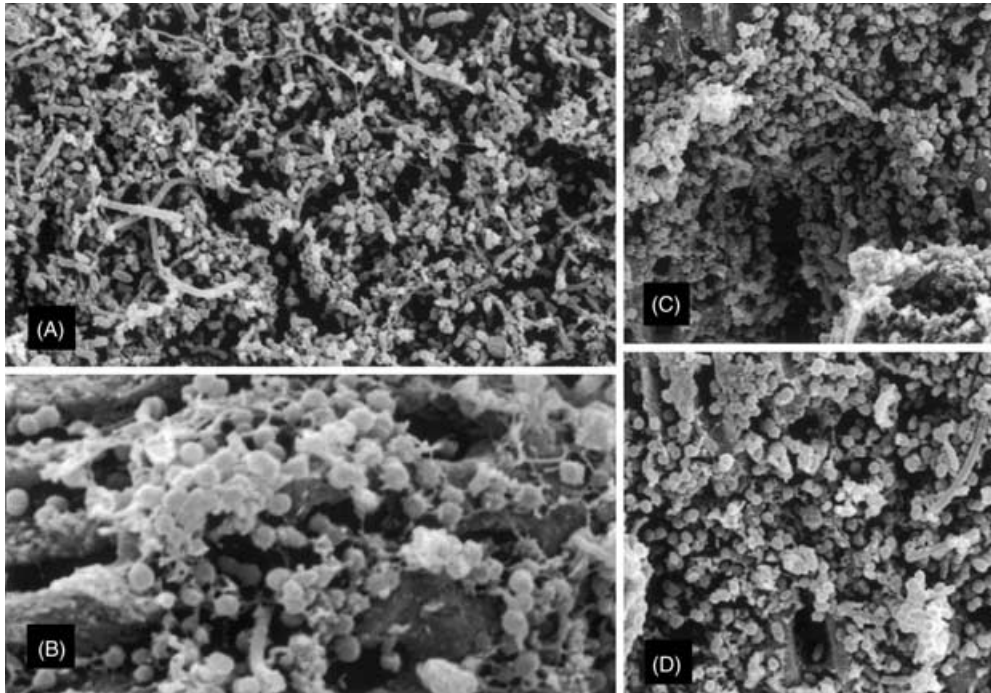
in causing an infectious flare-up as a result of apical extrusion of the debris (the role of host resistance should not be disregarded also!). However, all instrumentation techniques have been demonstrated to promote apical extrusion of debris, some more and others less (Al-Omari & Dummer 1995, Favieri *et al.* 2000). Crown-down techniques, irrespective of whether hand- or engine-driven instruments are used, usually extrude less debris and should be elected for the instrumentation of infected root canals. Therefore, the quantitative factor is more likely to be under control of the therapist. On the other hand, the qualitative factor is more difficult to control. When virulent clonal types of pathogenic bacterial species are present in the root canal system and are propelled to the periradicular tissues during instrumentation, even a small amount of infected debris will have the potential to cause or exacerbate periradicular inflammation. Intracanal occurrence of such virulent clones may also be the major reason for the fact that preoperatively symptomatic teeth are more predisposed to interappointment flare-ups than asymptomatic teeth.

#### Changes in the endodontic microbiota or in environmental conditions

The endodontic microbiota is usually established as a mixed consortium, and alteration of part of this consortium will affect both the environment and the remaining species. Studies that investigated the patterns of microbial colonization within the root canal system revealed that microbial organization often resembled the morphological characteristics of a climax community, a self-replicating entity in which bacteria exist in harmony and equilibrium with their environment (Molven *et al.* 1991, Siqueira *et al.* 2002b) (Fig. 3). In as much as the climax community contains many niches, many physiologically different microbial species can coexist indefinitely, provided they are functionally compatible.

Organization of microcolonies in the endodontic climax community may be dictated by the ecological determinants occurring in different parts of the root canal system. For instance, as both the oxygen tension and the oxidation–reduction potential of the coronal portion of canals are presumably higher than in other portions, facultatives and aero-tolerant anaerobes can predominate in such regions. On the other hand, the proportion of anaerobes is significantly higher in the apical third of the root canal (Fabricius *et al.* 1982), particularly because of the anaerobic conditions of the environment. This assumes ecological importance and allows the establishment and survival of determined species in the root canal system. Positive and negative interactions amongst the members of the microbial community allow the community to be relatively stable and in balance. Potent exogenous forces represented by chemo-mechanical preparation using antimicrobial irrigants and intracanal medication are needed to eliminate such climax communities. Ideally, the chemo-mechanical preparation should be completed in one appointment, and between visits, an intracanal medication should be left in the root canal. Incomplete chemo-mechanical preparation can disrupt the balance within the microbial community by eliminating some of the inhibitory species and leaving behind other previously inhibited species, which can then overgrow (Sundqvist 1992). If overgrown strains are virulent and/or reach sufficient numbers, damage to the periradicular tissues can be intensified, and this may result in lesion exacerbation (Fig. 4).

Endodontic procedures inevitably cause changes in the root canal environment. When microorganisms are not totally eliminated in the root canal system, environmental changes have the potential to induce virulence genes to be turned on or turned off. This is likely to be even more pronounced in cases of incomplete root canal instrumentation. Different and unpredictable

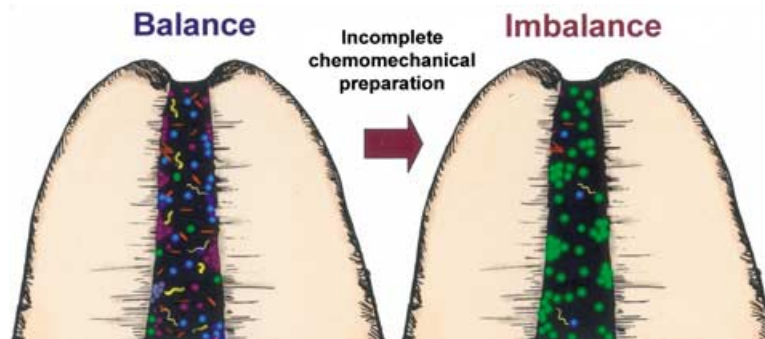


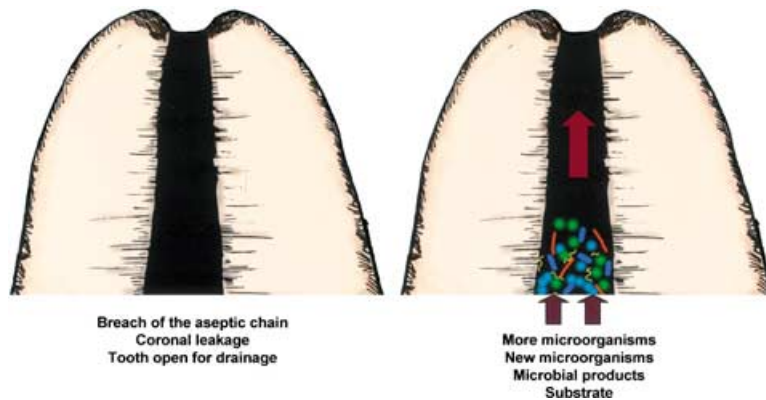
**Figure 3** Scanning electron micrographs showing bacterial organizations within infected root canals associated with periradicular lesions. (A) Bacterial mixed community, composed of different morphotypes, resembling climax communities (original magnification  $\times 3300$ ). (B) Colony composed mainly by cocci and also by scarce bacilli, adhered to dentine. Some cells are invading dentinal tubules (original magnification  $\times 4000$ ). (C and D) Mixed bacterial communities predominated by coccal forms adhered to the dentinal walls at the apical part of the root canal (original magnifications  $\times 1700$  and  $\times 1800$ , respectively).

consequences can follow induced intracanal environmental changes. For instance, when environmental changes induce turn-off of virulence genes, remission of the symptoms of previously symptomatic cases could ensue or even result in the success of the endodontic treatment even in situations where microorganisms are not completely eradicated from the root canal. On the other hand, when the environmental changes induce turn-on of virulence genes, a previously asymp-

tomatic case may become symptomatic or a persistent infection can establish itself in the root canal system. Persistent infections may be difficult to eradicate, and they are the main cause of treatment failure (Siqueira 2001a). Because it is clinically impossible to predict whether environmental changes will lead to turn-on or turn-off of virulence genes, chemo-mechanical preparation should be completed in one session, whenever it is possible.

**Figure 4** Incomplete chemo-mechanical preparation induces changes within the root canal system that may favour the overgrowth of certain species. If overgrown bacteria reach sufficient number and express virulence genes, they can induce damage to the periradicular tissues, and a flare-up may ensue.





**Figure 5** New microbial species, more microbial cells and substrate from saliva can be carried into the root canal system during treatment, between appointments or following treatment. If a secondary infection establishes itself, a flare-up may occur.

### Secondary intraradicular infections

Secondary intraradicular infections are caused by microorganisms that are not present in the primary infection and that penetrate the root canal system during treatment, between appointments or after the conclusion of the endodontic treatment. Introduction of new microorganisms into the root canal system during treatment usually occurs following a breach of the aseptic chain, and the main sources of recontamination include: remnants of dental plaque; calculus or caries on the tooth crown; leaking rubber dam; contamination of endodontic instruments, as for instance, after touching with the fingers and contamination of irrigant solutions or other solutions of intracanal use (such as saline solution, distilled water, citric acid, etc.) (Siqueira & Lima 2002).

Microorganisms can also enter the root canal system between appointments, after leakage through the temporary restorative material; breakdown, fracture or loss of the temporary restoration; fracture of the tooth structure and when the tooth is left open for drainage (Siqueira *et al.* 1998a).

Microorganisms can also penetrate obturated root canals in the following situations: leakage through the temporary or permanent restorative material; breakdown, fracture or loss of the temporary/permanent restoration; fracture of the tooth structure; recurrent decay exposing the root canal filling material or delay in the placement of permanent restorations (Siqueira *et al.* 2000a).

Secondary infections can occur in both vital and necrotic pulp cases. Regardless of the time of microbial introduction and whether penetrating microorganisms are successful in surviving into and colonizing the root canal system, a secondary infection may ensue and can be a cause of flare-up, provided the newly established microbial species are virulent and reach a sufficient

number to induce acute inflammation in the periradicular tissues (Fig. 5).

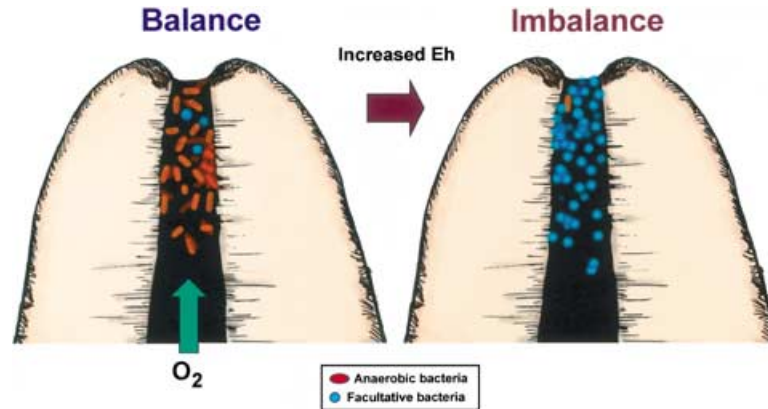
### Increase of the oxidation–reduction potential

It has been theorized that alteration of the oxidation–reduction potential (Eh) in the root canal environment can be a cause of exacerbation following the endodontic procedures (Matusow 1995). This theory is based on the fact that when the tooth is opened, oxygen penetrates into the root canal system, and the microbial growth pattern changes from anaerobic to aerobic. Energy yield of facultative anaerobes is more marked in the presence of oxygen than under anaerobic conditions, and a faster growth rate is expected. It is believed that if facultative anaerobes, such as streptococci, are present in the root canal infection and they resist intracanal procedures, they may overgrow as a result of the increase in the Eh potential and then deflagrate acute periradicular inflammation (Fig. 6). Proof of this theory is lacking and the proponent study is fraught with serious experimental flaws and questionable procedures: improper sampling procedures, initial office incubation before transfer to the laboratory, tooth left open for drainage and incomplete instrumentation at the initial appointment. Thus, there is no scientific evidence that this theory is true. In 1985, Irving Naidorf commented on this concept with considerable humour: 'So, this theory, as far as I am concerned, has such elegant simplicity that if it is wrong, I like it'. Although the possibility exists that this in fact occurs, it is only conjectural. If it is proved to be true it may be responsible for only a minority of flare-up cases.

### Preventive measures to infectious flare-ups

There are some patient-presenting factors that allow the professional to better predict the risks of flare-up. For

**Figure 6** Entrance of oxygen into the root canal during treatment may favour the overgrowth of facultative bacteria that resisted chemo-mechanical procedures. This mechanism is only conjectural, and there is no clear evidence substantiating this theory.



instance, a history of preoperative pain and/or swelling, particularly in cases of necrotic and infected pulps, is one of the best predictors of inter-appointment flare-ups (Torabinejad *et al.* 1988, Walton & Fouad 1992, Siqueira *et al.* 2002a). However, one should bear in mind that flare-ups are often completely unpredictable. Because all infected cases have theoretically increased risks to develop inter-appointment flare-ups, some preventive approaches should be selected for routine treatment of infected root canals. Based on the major microbial mechanisms involved in infectious flare-ups, the clinician should be motivated to follow some guidelines and adopt some clinical procedures that have the potential to prevent or at least reduce the incidence of flare-ups. They include: (i) selection of instrumentation techniques that extrude less amounts of debris apically; (ii) completion of the chemo-mechanical procedures in a single visit; (iii) use of an antimicrobial intracanal medicament between appointments in the treatment of infected root canals; (iv) not leaving teeth open for drainage; (v) maintaining the aseptic chain during intracanal procedures.

#### **Selection of instrumentation techniques that extrude less amounts of debris apically**

All instrumentation techniques are reported to cause apical extrusion of debris, even when preparation is maintained short of the apical terminus (Al-Omari & Dummer 1995, Lopes *et al.* 1997, Favieri *et al.* 2000). The difference resides in the fact that some techniques extrude more debris than others do. Techniques involving a linear filing motion usually create a greater mass of debris than those involving some sort of rotational action (Al-Omari & Dummer 1995). Crown-down techniques have also been demonstrated to extrude lesser

amounts of debris (Fairbourn *et al.* 1987, Al-Omari & Dummer 1995, Lopes *et al.* 1997, Favieri *et al.* 2000). Copious and frequent irrigation during chemo-mechanical procedures significantly enhances the removal of excised dentine, microbial cells and pulpal debris from the root canal (Baker *et al.* 1975, Siqueira *et al.* 2000b), reducing the risks of procedural accidents, such as blockages and apical extrusion of debris. As the amount of extruded debris may influence the response of the periradicular tissues, crown-down techniques using instruments with some sort of rotary action combined with abundant irrigation have at least theoretically the potential to reduce the risks of flare-ups.

#### **Completion of the chemo-mechanical procedures in a single visit**

Ideally, chemo-mechanical procedures should be completed in a single appointment. Maximum removal of irritants from the root canal system may reduce the risks of inter-appointment discomfort caused by surviving microbial species that either overgrow as a result of elimination of inhibitory species or become more virulent as a result of changes in the environmental conditions.

#### **Use of an antimicrobial intracanal medicament between appointments in the treatment of infected cases**

The use of an antimicrobial intracanal dressing is a valuable tool to control endodontic infections. Whereas some investigators have reported that intracanal medications have no influence on the incidence of postoperative pain (Torabinejad *et al.* 1988, Trope 1990), Harrison *et al.* (1981) have shown that the use of an antimicrobial intracanal medicament and sodium hypochlorite irrigation

can prevent postoperative pain. Recently, a low incidence of flare-ups in cases treated by undergraduate students who were using an antimicrobial strategy during therapy based on irrigation with sodium hypochlorite and intracanal medication with a calcium hydroxide/camphorated paramonochlorophenol/glycerin paste was reported (Siqueira *et al.* 2002a). Evidence indicates that intracanal medicaments are required for maximum microbial elimination in the root canal system and for killing microorganisms not reached by the instruments and irrigants (Byström *et al.* 1985, Byström *et al.* 1987, Siqueira 2001b). In addition, intracanal medicaments that temporarily fill the root canal, such as calcium hydroxide pastes, deny space for microbial proliferation between visits, and can play an important role in preventing the recontamination of the root canal between appointments (Siqueira *et al.* 1998a). Therefore, the use of antimicrobial intracanal medicaments has the potential to prevent postoperative pain caused by persistent intracanal microorganisms or by secondary microbial invaders, provided antimicrobial substances are not highly cytotoxic and are not extruded in significant amounts to the periradicular tissues. However, intracanal medicaments are highly unlikely to be effective in preventing flare-ups caused by extruded microorganisms during the chemo-mechanical procedures.

#### Do not leave teeth open for drainage

As early as in 1936, Alfred Walker argued against the practice of leaving teeth open for drainage: 'This method is as unscientific as it is antiquated (. . .). The practice of leaving the pulp canals of teeth open and unsealed for the purpose of drainage is contrary to the accepted surgical practice, is unnecessary and is, in consequence, a bad practice.' This practice is incoherent and detracts from sound biological principles of endodontic therapy. To leave the tooth open is the most direct way to permit the reinfection of the root canal system in addition to overcome any previous attempts to eradicate microorganisms within the root canal system.

Establishment of drainage followed by complete chemo-mechanical preparation, placement of an antimicrobial intracanal medication, and coronal closure at the same appointment result in a reduced risk of persistent symptoms as well as in fewer appointments to complete the therapy when compared with teeth left open for drainage (Weine *et al.* 1975, August 1982).

The quantity of purulent exudate at the periradicular tissues is obviously finite and actually forms in response to microorganisms present in the endodontic infection,

which are transiently invading the periradicular tissues. After proper drainage and once the source of infection (intraradicular microorganisms) is effectively controlled, no more purulent exudate will form, and the abscess will consequently resolve.

It is worth pointing out that even in the presence of diffuse swelling without any purulent discharge, the tooth should not be left open to await drainage. If the tooth is left open, more microbial cells, species, products and substrate are allowed to gain access to the root canal and the periradicular tissues. Even in the few circumstances in which complete root canal preparation followed by intracanal medication and proper coronal seal are not effective in promoting resolution, the practice of leaving the tooth open is not justifiable. In these cases, the amount of purulent exudates that are close to the apical foramen is limited once the infection is spreading through the bone, and the major amount of pus is on its way for submucous or subcutaneous drainage. If no pus drains through the root canal even after a slight widening of the apical foramen using small sterile files, it will not do even if the tooth is left open for many days.

#### To expend all efforts in maintaining the aseptic chain during intracanal procedures

Asepsis is paramount in endodontic therapy to prevent infection in vital cases or introduction of new microbial species in cases of infected necrotic pulps. Thus, clinicians should be aware of the need to perform endodontic treatment under strictly aseptic conditions as some cases of secondary infections may even be more difficult to treat than primary infections and may cause flare-ups, persistent symptomatology and/or failure of the root canal treatment (Siqueira 2002).

#### Conclusions

Even though it has been demonstrated that a flare-up has no significant influence on the outcome of endodontic treatment (Sjögren *et al.* 1990), its occurrence is extremely undesirable for both the patient and the clinician, and can undermine clinician-patient relationships. Therefore, clinicians should employ proper measures and follow appropriate guidelines in an attempt to prevent the development of inter-appointment severe pain and/or swelling (Table 1). Because microorganisms are arguably the major causative agents of flare-ups, knowledge about the microbial mechanisms involved in the aetiology of these phenomena is of utmost importance.



**Table 1** Microbial mechanisms in the induction of flare-ups and respective preventive measures

Microbial mechanisms	Preventive measures
Apical extrusion of infected debris	Crown-down instrumentation techniques Instruments used with some sort of rotation action Copious and frequent irrigation
Changes in the endodontic microbiota and/or in environmental conditions	Completion of chemo-mechanical preparation in a single visit  Placement of an antimicrobial intracanal medication that temporarily fills the root canal between appointments
Secondary intraradicular infections	Strict aseptic measures Proper coronal sealing Do not leave teeth open for drainage
Increase of the oxidation–reduction potential	Completion of chemo-mechanical preparation in a single visit Placement of an antimicrobial intracanal medication that temporarily fills the root canal between appointments

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