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Strategies for the endodontic management of concurrent endodontic and periodontal diseases

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ABSTRACT

Endodontic and periodontal diseases can provide many diagnostic and management challenges to clinicians, particularly when they occur concurrently. As with all diseases, a thorough history combined with comprehensive clinical and radiographic examinations are all required so an accurate diagnosis can be made. This is essential since the diagnosis will determine the type and sequence of treatment required. This paper reviews the relevant literature and proposes a new classification for concurrent endodontic and periodontal diseases. This classification is a simple one that will help clinicians to formulate management plans for when these diseases occur concurrently. The key aspects are to determine whether both types of diseases are present, rather than just having manifestations of one disease in the alternate tissue. Once it is established that both diseases are present and that they are as a result of infections of each tissue, then the clinician must determine whether the two diseases communicate via the periodontal pocket so that appropriate management can be provided using the guidelines outlined. In general, if the root canal system is infected, endodontic treatment should be commenced prior to any periodontal therapy in order to remove the intracanal infection before any cementum is removed. This avoids several complications and provides a more favourable environment for periodontal repair. The endodontic treatment can be completed before periodontal treatment is provided when there is no communication between the disease processes. However, when there is communication between the two disease processes, then the root canals should be medicated until the periodontal treatment has been completed and the overall prognosis of the tooth has been reassessed as being favourable. The use of non-toxic intracanal therapeutic medicaments is essential to destroy bacteria and to help encourage tissue repair.

Keywords: Endo-perio diseases, endodontics, periodontics.

INTRODUCTION

Although there are many factors that contribute to the development and progression of endodontic and periodontal diseases, the primary cause of both diseases is the presence of bacterial infections with complex microbial flora. Many authors have reported the similarity of the bacterial flora associated with endodontic and periodontal infections[1–5] and it is widely accepted that an untreated infection of one of these tissues can lead to signs or symptoms of disease within the other tissue.[6–10] Cross-seeding of bacteria from one tissue to the other can also occur[10] and this can occur in either direction (i.e., from the root canal to the periodontium, or vice versa) through communication pathways (Fig 1) such as the apical foramen, lateral canals, accessory canals (i.e., small canals that run from the floor of the pulp chamber to the furcation region of multi-rooted teeth), dentinal tubules, developmental defects (e.g., radicular grooves, invaginations) and other disease-related or iatrogenic defects of the tooth root (e.g., caries, cracks, perforations).

Once both the pulp and the periodontal tissues have become involved, the diagnosis and management of the situation may become more complex and will require extra considerations. The prognosis will be less predictable and patients may be unwilling to commit themselves to the treatment, as well as the financial and time burdens required to salvage the tooth, and to retain and maintain it in the long term.[11]

Traditional approaches to assessing and managing teeth with concurrent endodontic and periodontal diseases have been somewhat confusing as a result of inconsistent, inaccurate and confusing terminology. Although there has been considerable research about this topic in the past, there has been little research reported in the last decade. The aims of this paper were to review the literature, to develop a simple classification system and to provide a rational approach to managing teeth with concurrent endodontic and periodontal diseases.

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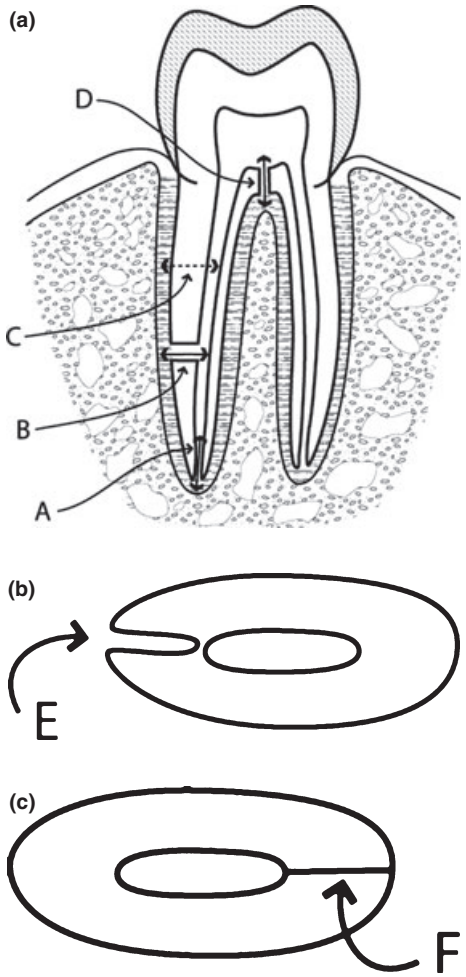

Fig 1. Schematic representation of some of the possible communication pathways between the dental pulp and the periodontal ligament. (a) Longitudinal section of a tooth and its periapical and periodontal tissues. A – the apical foramen; B – a lateral canal; C – dentinal tubules; D – an accessory canal. (b) – Cross-section of a tooth root. E – a radicular groove or invagination. (c) Cross-section of a tooth root. F – a crack in the tooth root.

Previous discussions of this topic have typically included all interactions between the dental pulp and the periodontal tissues rather than being limited to teeth with concurrent endodontic and periodontal diseases. In this paper, only the latter will be discussed in detail but a brief outline of the former will be provided to assist with the understanding of the proposed classification system.

Pulp and periapical conditions that may have periodontal manifestations

Some endodontic diseases may have manifestations that affect the periodontal tissues. In particular, a chronic apical abscess may appear to be associated with a periodontal pocket. A chronic apical abscess is defined as a localized collection of pus with a draining sinus – the abscess is located in the periapical region of a tooth

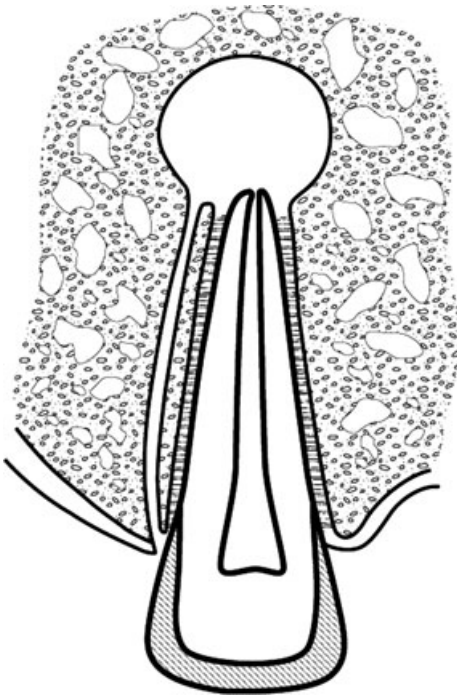

Fig 2. Schematic representation of a chronic apical abscess with a draining sinus tracking alongside the periodontal ligament and exiting the tissues inside the gingival sulcus, giving the clinical appearance of a deep narrow periodontal pocket. The root canal system is pulpless and infected.

and is typically a result of an infected root canal system. The draining sinus may exit the mucosa in any location, either close to or at some distance from the abscess. In some cases, the draining sinus may be located immediately adjacent to, or alongside, the gingival sulcus (Fig 2) and this can have the appearance of a deep, narrow periodontal pocket.[12] In other cases, the draining sinus may be tracking through the periodontal ligament itself, although this would seem unlikely to occur in a tooth with a healthy periodontal ligament.[12] The furcation region of multi-rooted teeth may have a radiolucency (Fig 3) if there are accessory canals draining into the furcation. The root canal infection may be in one or more canals and may occur in teeth that have pulpless and infected root canal systems or in teeth that have been previously endodontically treated (Fig 3). Irreversible pulpitis rarely, if ever, will cause periodontal or osseous defects, although it is possible that one canal may have irreversible pulpitis while one or more of the other canals or the pulp chamber is infected – this situation has been termed ''pulp necrobiosis''.[13,14] The history together with the clinical and radiographic examination will generally reveal a factor that has caused the pulp necrosis and subsequent infection (e.g., caries, a crack, marginal breakdown of a restoration, trauma, etc.).

Chronic apical abscesses have little or no discomfort unless an acute exacerbation occurs such as when the draining sinus closes but pus is still being produced and

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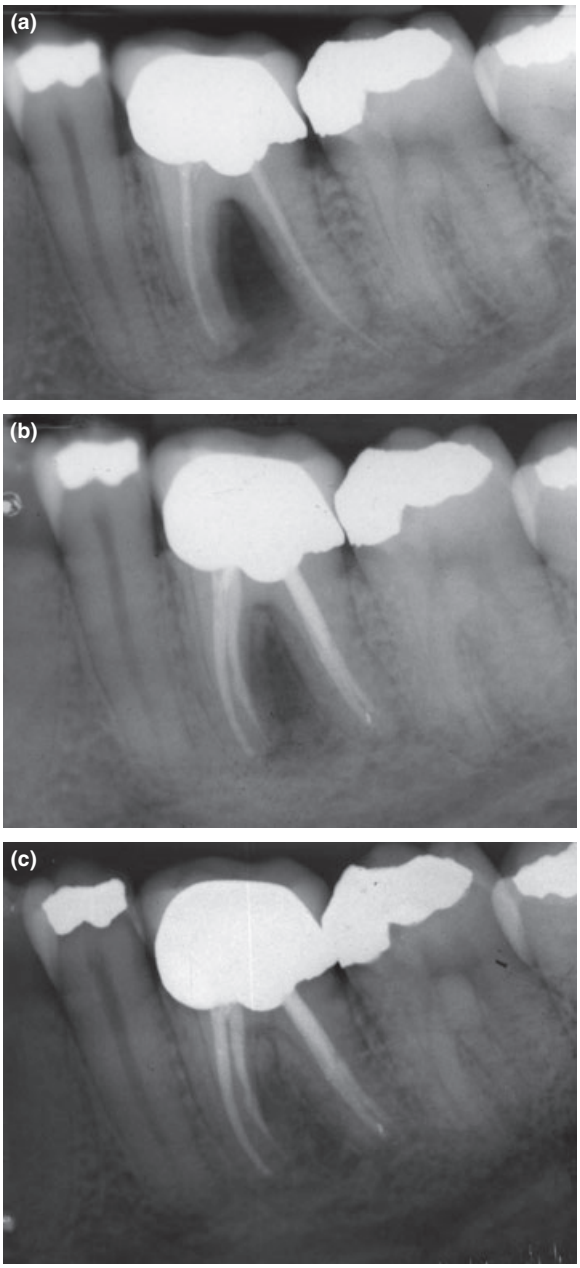

Fig 3. An example of how a tooth with a chronic periapical abscess may appear to also have a periodontal pocket. The management of this situation is also illustrated by this case. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*). (a) Pre-operative radiograph of a root-filled lower left first molar tooth that had an infected root canal system and a chronic apical abscess. The draining sinus was located on the mid-buccal aspect of the tooth with its external opening being inside the gingival sulcus, thus appearing to be a deep narrow periodontal pocket. The root canal filling was technically inadequate with only two of the four canals having been treated previously. The periapical radiolucency extended to the furcation region of this tooth. (b) Periapical radiograph taken immediately after placing the root canal filling which was done three months after removal of the previous root canal fillings, thorough cleaning, irrigation and medication of all four canals with a 50:50 mix of Ledermix and calcium hydroxide pastes. Early radiographic signs of periapical and furcation bone repair are evident and there were no further clinical signs of a draining sinus after the initial cleaning of the root canal system. (c) Six-month review radiograph shows complete bone repair. Clinically, there were no signs of a draining sinus and no periodontal treatment was required at any stage.

is trapped deep within the tissues. The diagnosis of these cases should be based on the status of both the root canal system and the periodontal tissues (e.g., a pulpless, infected root canal system with a chronic apical abscess as a result of caries). Comprehensive clinical classifications have been suggested for the status of the periapical tissues[15] and for the pulp and root canal system.[14] In addition to noting the diseases that have been diagnosed in such cases, the clinical record should also include a notation regarding the presence and location of the draining sinus/periodontal defect so its presence and healing can be reassessed following the initiation of treatment.

Periodontal conditions that may affect the pulp and/or periapical tissues

Periodontal diseases may lead to changes in the state of the pulp tissue in several ways. Pulp inflammation (pulpitis) and secondary dentine formation has been reported as being associated with periodontal diseases,[6,7] as has internal resorption.[6] These pulp changes were reported to only occur when the periodontal pockets extended deep enough to involve lateral canals or dentinal tubules associated with exposed root dentine or root caries.[6,7] Complete pulp necrosis did not occur unless the periodontal pocket extended all the way to the main apical foramen and the foramen had been invaded by plaque.[6,7] Once complete pulp necrosis occurs, infection of the root canal system is to be expected with the subsequent development of apical periodontitis since bacteria from the periodontal pocket may invade the necrotic pulp tissue once the pulp has lost its ability to resist such bacterial invasion.

Periodontal treatment may also cause pulp inflammation, although usually only in the form of reversible pulpitis which subsequently resolves after one to two weeks but may occasionally persist and become irreversible pulpitis. Root planing is an operative procedure of the tooth that may cause pulp inflammation of varying degrees, depending on the extent of the procedure itself, the amount of cementum removed, whether the exposed dentine is protected by a smear layer and the ability of the pulp to respond to any irritant. The latter is usually entirely dependent on the overall health of the pulp and this also depends to some extent on the history of any previous insults to the pulp and whether these caused pulp fibrosis in the portion of the pulp that is being irritated by the periodontal treatment. Typically, patients with reversible pulpitis report sensitivity of the root-planed tooth to cold stimuli, and occasionally sensitivity to hot stimuli. The pain induced by the stimulus usually only lasts for a few seconds after the stimulus has been removed, and then resolves within one to two weeks.

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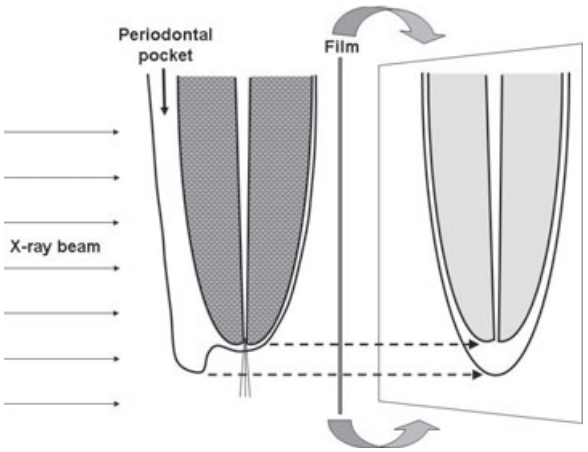

Fig 4. Schematic representation of a periodontal pocket mimicking a periapical radiolucency. Note that the apical blood vessels and pulp's nerve supply are intact. If the tooth is not carefully examined and tested with pulp sensibility tests, this radiographic ''lesion'' could be mistaken as being a sign of chronic apical periodontitis because of pulp necrosis and infection of the root canal system. (Reproduced with permission and courtesy of Wiley-Blackwell, publishers of *Endodontic Topics*.)

In some patients, the bone loss associated with a very deep periodontal pocket may extend beyond the root apex. In this situation, it can mimic a periapical radiolucency[15] which may suggest that the tooth has an infected root canal system with chronic apical periodontitis (Fig 4). A careful and thorough examination of the tooth, which must include pulp sensibility testing, is essential in these cases to ensure that an incorrect diagnosis is not made since this will lead to unnecessary and incorrect treatment of the problem. Teeth with infected root canal systems should be expected to have a reason for the pulp necrosis to have occurred (e.g., caries, cracks, breakdown of restorations, fractures, trauma, etc.) and there should be a pathway of entry for the bacteria to have reached the root canal system in order to establish the infection. If neither the reason for necrosis nor the pathway of entry for the bacteria can be established, then the diagnosing clinician should be suspicious of a periodontal pocket that is mimicking a periapical radiolucency, and appropriate referral or management should be instigated. The pocket and the pulp can then be reassessed further after a period of time for initial healing.

Classification of endodontic-periodontal diseases

Several classifications of the so-called ''endo-perio lesion'' have been suggested in the dental literature but most of these are not entirely satisfactory. A commonly-used classification for endodontic-periodontal diseases was first suggested by Simon *et al.*[16] and later modified by Gargiulo.[17] This classification included five categories which were based on the concept of having primary and secondary diseases: (1) primary endodontic lesion; (2) primary endodontic lesion with secondary periodontal involvement; (3) primary periodontal lesion; (4) primary periodontal lesion with secondary pulp involvement; and (5) ''true combined'' endodontic-periodontal lesion.

However, this classification is not universally accepted as it is confusing. The confusion arises from the terminology used since the two primary conditions are essentially ''single site'' diseases (i.e., solely endodontic or periodontal diseases) and, as such, they are not combined endodontic and periodontal diseases.[11] In addition, when there are ''secondary'' diseases present, it is not usually possible to distinguish these from ''true combined'' lesions since it is not possible to determine which tissue was the first one to be affected, or infected.[11]

Weine[18] proposed a classification based on treatment needs rather than on the diagnosis of the problem. Such a classification is unacceptable since the disease should be diagnosed before considering the treatment required, rather than the other way around. In addition, treatment needs can vary considerably for different cases with the same disease process and therefore this classification can be misleading. Another classification, proposed by Guldener,[19] was based on both the cause of the disease(s) and the treatment needs rather than just on the cause. His classification also included other problems and conditions (such as perforations, root resorption, root fractures, invaginations, grooves, etc.). Whilst it is recognized that these other problems can involve both the pulp and the periodontal tissues, they are not strictly combined or concurrent endodontic and periodontal diseases since they have particular reasons and/or causes for the condition. As an example, a vertical root fracture usually has an infected root canal system and a periodontal infection but these infections are a direct result of the fracture – hence the tooth should be diagnosed as having ''a vertical root fracture that is infected and causing apical periodontitis and a periodontal abscess'' (although such a fracture could also manifest as other periapical and/or periodontal conditions). Whilst it could be argued that all interrelationships between endodontic and periodontal conditions should be included in a classification of endodontic and periodontal diseases, having such a broad classification is unnecessary since these conditions are specific problems with their own diagnostic criteria and recommended management protocols. In addition, they are not all diseases or lesions – such as developmental conditions. Guldener's classification also has the same disadvantage of Weine's classification in that it uses treatment needs to classify the diseases rather than the signs, symptoms and causes of the disease.

Another commonly-used classification was first suggested in a textbook chapter by Torabinejad and Trope[20] and was based on the origin of the periodontal pocket, as follows:

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(1) Periodontal pocket of endodontic origin;
(2) Periodontal pocket of periodontal origin;
(3) Combined endodontic-periodontal lesion;
    - separate endodontic and periodontal lesions without communication
    - endodontic and periodontal lesions with communication.

However, the first two categories of this classification are essentially ''single site'' diseases which are not combined endodontic and periodontal diseases[11] even though each one may have some affect on the other tissue, as discussed above. Interestingly, a later edition of the same textbook did not use this classification again and instead reverted to the classification suggested by Simon *et al*.[16] although there were different authors for this chapter in the later edition.[21]

A clinically useful classification should be clear and easy to understand. It should also be based on information that can be obtained from the history provided by the patient along with the findings of the clinical examination and other diagnostic procedures such as percussion, palpation, mobility testing, pulp sensibility tests, periodontal probing and periapical radiographs which are all particularly useful, and essential, for diagnosing endodontic and periodontal conditions. It is therefore proposed that the classification of endodontic and periodontal diseases be limited to those teeth that have both endodontic and periodontal diseases occurring at the same time – hence, it is proposed that they should be called ''concurrent diseases'' rather than ''combined endo-perio lesions'' since the suggested term is more appropriate as well as being more accurate, clinically useful and easy to use. Hence, only two categories are required, as follows:

(1) Concurrent endodontic and periodontal diseases without communication

This applies to a tooth that has an infected root canal system with some form of apical periodontitis PLUS marginal periodontal disease with pocketing but the periapical and periodontal diseases do not communicate with each other (Fig 5). That is, clinically when probing the periodontal pocket it does not extend as far as the periapical lesion; radiographically the periodontal pocket does not extend as far as the apical foramen of the root canal, and bone can be seen between, and separating, the periapical radiolucency and the base of the periodontal pocket.

(2) Concurrent endodontic and periodontal diseases with communication

This applies to a tooth that has an infected root canal system with some form of apical periodontitis PLUS marginal periodontal disease with pocketing that extends to the periapical lesion such that the periapical and periodontal diseases communicate with each other; radiographically the periodontal pocket and the periapical radiolucency appear as one radiolucency, and there is no bone between the periapical radiolucency and the base of the periodontal pocket (Fig 6).

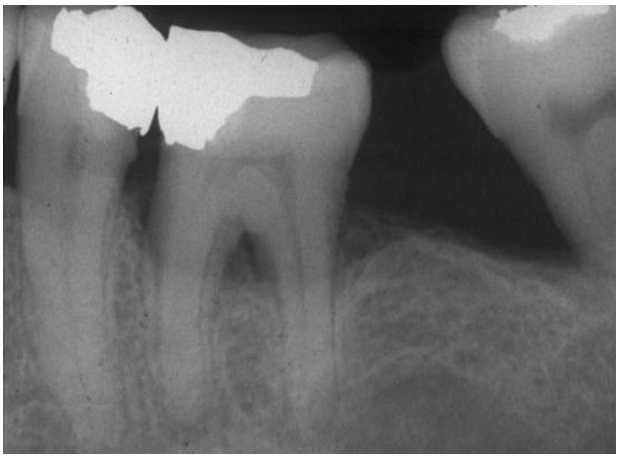

Fig 5. A lower left first molar tooth with concurrent endodontic and periodontal diseases that do not communicate. This tooth has a pulpless, infected root canal system with chronic apical periodontitis as a result of breakdown of the amalgam restoration and the presence of mesial caries. There was no response to pulp sensibility testing and the radiograph shows a small periapical radiolucency associated with the mesial root. The patient has generalized marginal periodontal disease with the typical deep, wide-based periodontal pocket seen with periodontal disease. The radiograph shows more advanced crestal bone loss associated with this tooth than with the adjacent teeth which have clinically normal pulps. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*.)

Teeth that have concurrent endodontic and periodontal diseases have two simultaneously-occurring disease processes and fortunately they are relatively uncommon although incidence data has not been published in the literature. One disease process is the periapical inflammatory response that has developed as a result of infection of the root canal system, whilst the other disease process is an independent periodontal pocket that is progressing towards the root apex – this periodontal pocket is a result of bacteria-induced periodontal disease. Initially the diseases do not communicate (Fig 5) but if they are left to progress over a period of time, then they may eventually meet (Fig 6).

Teeth with concurrent endodontic and periodontal diseases will have clinical and/or radiographic signs of both endodontic and periodontal involvement. The diagnosis of both conditions can usually be made after a thorough clinical and radiographic examination. Endodontic diseases are largely diagnosed via a combination of the results of pulp sensibility tests and the radiographic observations with the latter providing very definitive evidence of the presence of an infected root canal system.[22] This was clearly shown in a monkey study where the radiographic periapical

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Fig 6. A lower right first molar tooth with concurrent endodontic and periodontal lesions that communicate. This tooth has a pulpless, infected root canal system with a chronic apical abscess as a result of breakdown of the amalgam restoration and the presence of distal caries. There was no response to pulp sensibility testing and the radiograph shows a gutta percha ''tracer point'' placed in the distal periodontal pocket which demonstrates that the pocket extends to, and communicates with, the periapical radiolucency associated with the distal root. The patient has generalized marginal periodontal disease with the typical deep, wide-based periodontal pocket seen with periodontal disease. The radiograph shows significant crestal bone loss associated with this tooth whereas the adjacent teeth have not had much bone loss. The adjacent teeth also have clinically normal pulps. The food pack between the first and second molar teeth is a likely contributory factor to both the endodontic and periodontal problems being experienced with the first molar tooth. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*.)

changes – such as a widened periodontal ligament space, loss of lamina dura, and a periapical radiolucency – only occurred once the root canal system had been infected for some time.[22] The periapical radiographic signs were not visible until 2–4 months, and even up to more than 10 months in some cases, after the canals had been intentionally infected with bacteria. Inflammatory changes in the periapical region were noted histologically well before the radiographic signs could be seen. Therefore, once a periapical radiolucency is present, a diagnosis of an infected root canal system will be accurate and reliable although practitioners should always be aware of the possibility that the radiolucency may indicate other pathosis that is unrelated to the condition of the pulp or root canal system.[15]

The diagnosis of periodontal diseases is usually based on a combination of the findings of periodontal probing and radiographic examination. Periodontal disease leads to periodontal pockets with distinct probing patterns – the defects are usually wide-based and cone-shaped with the probe ''stepping down'' progressively to deeper levels, followed by ''stepping up'' on the other side of the pocket.[17,23] This probing pattern markedly differs from that of the deep, narrow defect associated with chronic apical abscesses (as discussed above), vertical root cracks and fractures that have become infected. Radiographs usually show generalized vertical and horizontal bone loss along the root surfaces at various levels, and there are usually multiple teeth with periodontal disease rather than just a single tooth whereas, in contrast, it is uncommon (although possible) for patients to have multiple teeth with infected root canal systems at the same time.

Concurrent endodontic and periodontal diseases usually do not present with any symptoms unless an acute exacerbation of one of the infections has occurred – such as an acute apical abscess or an acute periodontal abscess. In such a situation, the usual diagnostic criteria can be applied to differentiate between these two types of abscesses so appropriate treatment can be instigated as soon as possible.

Differential diagnosis

The most important part of managing any disease is to establish the correct diagnosis. This is just as important when dealing with concurrent endodontic and periodontal diseases as an accurate diagnosis will then lead the clinician to an appropriate management plan. The diagnosis must be based on a combination of the history obtained from the patient, the clinical examination findings, the radiographic observations, and the results of all tests and investigations. In particular, pulp sensibility tests (ideally both thermal and electric), periodontal probing, palpation, percussion, mobility testing, transillumination of the tooth, and removing existing restorations are valuable and essential diagnostic steps to help differentiate between pulp/periapical diseases and periodontal diseases.[11] Table 1 summarizes the common clinical and radiographic findings when examining a patient for endodontic and periodontal diseases.

The clinical diagnosis of the pulp status can be difficult at times. Unfortunately, there is no single test available that will accurately and reliably determine the true status of the pulp or root canal in all cases. The commonly-used thermal and electric pulp sensibility tests can only indicate the ability of the pulp's nerve supply to respond to that particular stimulus. These tests do not provide any information about the presence or absence of the pulp's blood supply, which is more relevant when determining whether the pulp is healthy or diseased.[14] However, reliable pulp and root canal diagnoses can be made with a thorough understanding of the disease processes, the nature of the test and the meaning of the test results.

Pulp sensibility tests cannot be interpreted accurately without the use of periapical radiographs since conditions such as pulp canal calcification, previous root fillings, pulpotomies, porcelain crowns, etc., can lead to

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Table 1. Typical findings of clinical and radiographic examinations when assessing pulp and periapical diseases, periodontal diseases and concurrent endodontic and periodontal diseases. These findings can be used to differentiate between these different diseases. *CODE:* Yes = this finding is usually present; No = this finding is not usually present. However, there are many variations which must be assessed for each individual case with appropriate diagnostic tests and a thorough clinical and radiographic examination

Typical findings	Pulp and periapical diseases	Periodontal diseases	Concurrent endodontic and periodontal diseases
Disease process localized to just one tooth	Yes	No	Yes – but may have more than one tooth involved if the patient has generalized marginal periodontal disease
Extensive caries or restorations	Yes	No	Yes – likely there is pulp/periapical disease present
Responds to pulp sensibility tests	No	Yes	No – due to the pulp/periapical disease process
Periodontal probing defect	No – but may have a deep, narrow probing defect if there is a draining sinus that exits in the gingival sulcus	Yes – usually a deep, wide-based pocket	Yes – usually a deep, wide-based pocket due to the periodontal disease process
Crestal bone loss evident on radiographs	No	Yes	Yes – usually a deep, wide-based pocket due to the periodontal disease process
Periapically – loss of lamina dura or the presence of a radiolucency	Yes	No	Yes – due to the pulp/periapical disease process
Tenderness to percussion and/or palpation	No – unless acute apical periodontitis or acute apical abscess is present; may "feel different" if chronic apical periodontitis is present	No – unless acute periodontal abscess is present; may "feel different" if chronic marginal periodontitis is present	No – unless acute apical periodontitis, acute apical abscess or acute periodontal abscess is present; may "feel different" if chronic apical periodontitis or chronic marginal periodontitis is present

false test results. Hence, good quality diagnostic radiographs are essential for the diagnosis of all endodontic and periodontal diseases. Radiographs should be used to determine whether the periapical and periodontal regions are involved, to determine the size, shape and extent of any bone loss, and to assess whether other diseases or causative factors are present – such as caries, an overhang, a deep restoration, etc. Radiographs and pulp sensibility tests are also essential to help differentiate between odontogenic and non-odontogenic lesions. All radiographs should be taken with film holders that incorporate beam guidance so that a parallel view is obtained since this provides the most accurate representation of the tooth and its supporting structures. Beam guidance devices also help to ensure that a reproducible view is obtained so subsequent films of the same tooth can be compared to the initial film. This is extremely important when assessing the healing response after treatment or if further problems develop in the future.

Teeth with previous endodontic treatment must be assessed with extreme caution since radiographs do not provide information regarding the quality of the endodontic treatment or the root canal fillings.[24] Radiographs essentially only show how radiopaque the root filling material is and where the material has been placed.[25] It is important to recognize that a tooth with a radiographically-determined good root canal filling can still contain bacteria[24] and this must be considered carefully when formulating a management plan for diseased teeth.

Radiographs can also be misleading if not interpreted cautiously – such as when a periodontal pocket mimics a periapical radiolucency,[15] as outlined earlier and shown in Fig 4.

Important considerations for managing concurrent endodontic and periodontal diseases

There are many factors that may affect the progression of both endodontic and periodontal diseases. These factors may also affect the outcome of any treatment provided. When treating teeth with concurrent endodontic and periodontal diseases, there are also the additional effects of the treatment of one tissue on the partner tissue that need to be considered.[11] Research has clarified some of the interactions between these two disease processes and the results of these studies can be used to formulate a logical sequence for treating concurrent diseases. In particular, care must be taken to minimize the risks of cross-seeding of bacteria[10] whilst also providing optimum conditions in which

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periapical and periodontal healing can occur. The major findings of a number of important studies are summarized below.

(1) Infected root canal systems and periodontal pockets have similar microbiological flora[2,4,5,8–10] although there are more spirochaetes in periodontal pockets than in infected root canal systems. Several studies[1,3,5] have shown that 30–60 per cent of the microbial flora in periodontal pockets are spirochaetes whereas 0–10 per cent of the organisms from infected root canal systems are spirochaetes. In general, there are more microbes and more species in periodontal pockets than in infected root canal systems, and the microflora in infected root canals of teeth that have concurrent endodontic and periodontal diseases is more complex than in teeth with pathosis confined to the periapical region.[5]

(2) The periodontal pocket may be a source of bacteria for the root canal system[8–10] or vice versa, and cross-seeding of bacteria can occur in either direction.[10]

(3) The long-term prognosis for periodontally-involved teeth is more favourable for teeth with clinically normal (i.e., healthy) pulps than for endodontically-treated teeth as demonstrated by Jaoui *et al*.[26] In that study, 6 per cent of the 195 endodontically-treated teeth were extracted over eight years after periodontal treatment whereas none of the 521 teeth with clinically normal pulps were extracted during this time.

(4) Lindskog *et al*.[27] demonstrated that periodontal healing adjacent to cementum favours connective tissue formation whereas healing adjacent to dentine favours rapid downgrowth of gingival (i.e., long junctional) epithelium. This strongly suggests that treatment should be sequenced to take advantage of the more favourable healing response associated with the presence of cementum, especially when the root canal is also infected (see below).

(5) A series of studies[22,28–32] concerning the influence of infected root canal systems on marginal periodontitis in monkeys and periodontitis-prone human patients clearly demonstrated that:

- an intracanal infection can invoke an inflammatory response along the lateral surfaces of a tooth root;
- intracanal infections were correlated with deeper periodontal pockets, more loss of attachment, and more marginal epithelium in periodontitis-prone patients;
- the average radiographic attachment loss in teeth with an infected root canal system in periodontitis-prone patients over a six-year period was significantly higher than the radiographic attachment loss caused by marginal periodontitis in teeth with normal pulps;
- the influence of an intracanal infection was at least of the same order of magnitude as a risk factor for periodontal disease as an overhanging restoration.

(6) Local factors that modify marginal periodontal healing have been investigated in monkeys and with clinical studies in periodontitis-prone human patients.[33–35] These studies showed that:

- infected root canal systems had significantly larger areas of external inflammatory and replacement root resorption when dentine surfaces had been exposed through removal of cementum;
- periodontal healing was at risk of being impaired when the root canal system was infected;
- following non-surgical periodontal treatment, the mean reduction of periodontal pocket depth was significantly less over time in the presence of infected root canal systems compared to teeth with clinically normal pulps.

(7) Jansson[36] and Ehnevid[37] have both stated that endodontic infections must not be overlooked and should be given priority in treatment planning for periodontitis-prone patients.

When planning treatment of concurrent endodontic and periodontal diseases, the above findings strongly indicate that the timing of the endodontic treatment is an important consideration. As mentioned above, a root canal infection has significant effects on the outcome of periodontal treatment. However, in addition to this, the outcome of endodontic treatment may be affected if the root canal filling is placed while there is still a periodontal infection present that communicates with the root canal system since cross-seeding through the apical or lateral foramina is possible. Despite thorough cleaning and disinfection of the root canal system during endodontic treatment, bacteria from the periodontal lesion may re-invade the root canal system since root canal fillings do not seal canals completely.[38,39] Root canal fillings may ''fill'' the canal space but there is no technique or material available that has been shown to provide a total, predictable and long-term ''seal'', as demonstrated by over 150 apical penetration studies of root canal fillings.[39] However, fortunately, the environment within the root canal system can be maintained in a state that is unfavourable for bacterial colonization by using an anti-bacterial medicament within the canals[40,41] during the periodontal treatment, particularly if the dressing is replaced at regular intervals.[42,43]

The use of an intracanal medicament is considered by many authorities to be essential when treating an infected root canal system. Although there has been a trend over the last 10–15 years by some practitioners to use ''one-visit'' endodontic procedures on a routine basis, this approach is not supported by the scientific evidence in the dental literature. In particular, there are no well-documented long-term scientific studies

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that demonstrate the outcome of ''one-visit'' endodontics. Proponents of this approach use a few studies that have reported no difference in postoperative pain or short-term success rates of 6–12 months. Neither of these aspects prove that the treatment is adequate at removing the intracanal infection and they contradict the comprehensive work of Byström *et al*.[44–46] These studies clearly showed that the mechanical cleaning of a root canal (i.e., filing) and disinfectant irrigating solutions will reduce the bacterial count but they will not completely eliminate all organisms. The use of anti-bacterial intracanal medicaments are also required to predictably achieve bacteria-free canals prior to placing a root filling. Two comprehensive clinical and microbiological studies[47,48] have confirmed this and shown that there is a significantly lower rate of healing for ''one-visit'' endodontic treatment when bacteria were isolated from the canals after instrumentation but prior to root filling. The teeth that had no bacteria isolated prior to the root filling had a 26 per cent higher rate of healing in one study[47] and 47 per cent difference in another.[48] Other studies[49–52] have also shown similar results and clearly demonstrate that it is not possible to predictably remove or inhibit all bacteria in an infected root canal system just by the mechanical cleaning with files and irrigation with disinfectant solutions. Hence, intracanal medication is highly recommended in order to improve the predictability of disinfection of the canals and in turn to improve the predictability of the outcome of endodontic treatment.

If it is accepted that an intracanal medicament is needed, then the type of medicament to use is important. The use of a biocompatible medicament is essential to promote periodontal healing[53] and therefore increase the overall prognosis for the tooth. Ledermix paste (Lederle Laboratories, Seefeld, Germany), a corticosteroid-antibiotic combination, has been shown to be effective as an antibacterial agent within the root canal system and its anti-inflammatory action can reduce symptoms by decreasing the periodontal and periapical inflammation.[42,43,54,55] The corticosteroid component of this material is also a very effective inhibitor of clastic cells[56] and will help to reduce the incidence of external inflammatory root resorption.[57] Further inhibition of root and bone resorption, and stimulation of bone healing is provided by the tetracycline component[58] since tetracyclines are potent inhibitors of osteoclasts and they bind to bone and tooth. This binding to tooth structure helps to maintain the drug in the local region for a sufficient period of time to allow periodontal healing to occur. Tetracyclines also inhibit polymorphonuclear lymphocyte collagenase, an enzyme which leads to tissue destruction – hence the use of Ledermix paste can help to reduce tissue breakdown.[58]

Calcium hydroxide is also a very effective antibacterial agent when used within the root canal system and it has been shown to stimulate hard tissue repair. However, the latter effect is a result of its high toxicity which causes surface necrosis to occur. This toxic effect of calcium hydroxide is undesirable in tissue that is already inflamed as a result of the disease process and therefore the application of calcium hydroxide in the early stages of treatment may initiate or exacerbate external inflammatory root resorption if cementum is missing or has been removed through root planing. Long-term use of calcium hydroxide is also associated with significantly more ankylosis and external replacement root resorption of teeth that have had damage to the external root surface, such as after trauma or periodontal disease and its treatment.[53,59-61] Hence, calcium hydroxide must be used with care when any cementum is missing. In addition, calcium hydroxide cannot be relied upon to eliminate all bacteria in all cases – as demonstrated by several studies.[46,62] This is a problem associated with all medicaments and provides support for the use of more than one medicament in infected teeth, either as separate dressings or in combination. It is believed that combining Ledermix paste with calcium hydroxide will reduce the toxicity of the calcium hydroxide whilst still maintaining the therapeutic properties of each active component and increasing the antibacterial spectrum of activity compared to when using Ledermix paste alone.[42,43,63,64]

General management strategies for endodontic and periodontal infections masquerading as other diseases

Periodontal diseases that appear to be causing pulp changes should initially be managed conventionally by thorough subgingival root planing, by removal of any local causative factors and with oral hygiene instruction. This should be followed by review and reassessment of the healing response. Some cases will require further root planing and/or surgical management to gain better access to the root surface for plaque and calculus removal. If the pulp symptoms continue, then endodontic examination, diagnosis and management will be indicated. Since periodontal diseases and their treatment can cause pulp changes, it is essential to regularly re-examine periodontally-involved teeth for any changes in the status of the pulp and periapical tissues. This includes repeating pulp sensibility tests at review examinations and comparing the results to those obtained at the initial examination. Any teeth that are susceptible to pulp changes and those with altered pulp sensibility test results should have further periapical radiographs taken and compared to the diagnostic films taken prior to treatment. The status of the pulp is dynamic and it may change over time since the pulp is a tissue that is capable of responding to

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stimuli and changing conditions. Repeated insults will lead to pulp fibrosis and a reduced capacity to respond normally[63] and therefore pulp necrosis may occur at any time in compromised teeth with subsequent infection of the root canal system and then apical periodontitis.

Conventional endodontic treatment of an infected root canal system with a chronic apical abscess draining alongside or through the periodontal ligament (Fig 1) should lead to healing of the apical abscess. If the draining sinus masquerading as a periodontal pocket does not heal, then periapical surgery is usually indicated so the apical abscess can be curetted. Ideally, such surgery should be done at the same time as the placement of the root canal filling in order to avoid the possibility of any extra-radicular bacteria re-infecting the filled root canal which may occur if the canal is filled some time prior to surgery. If the periodontal defect still does not heal after periapical surgical intervention, then periodontal diagnosis and management may be required. After the root canal filling has been completed, the tooth should be restored with a suitable restoration and scheduled for review. Every tooth that has undergone endodontic treatment should be reviewed clinically and radiographically after 6–12 months in order to determine whether adequate periapical healing has continued. If periapical healing is evident and the periodontal situation is stable, then further clinical and radiographic reviews should be conducted every 3–4 years to monitor the tooth, its periodontium and its restoration. As both endodontic and periodontal infections can recur, it is essential to review and maintain the area so that early signs of breakdown can be treated before irreversible damage occurs or before the required treatment becomes further complicated.

Specific points to be emphasized in treating any tooth with an infected root canal system include:

- the treatment should be carried out under aseptic conditions using rubber dam isolation for all phases of the treatment including the final coronal restoration;
- the treatment should address the factor(s) that has/have caused the intracanal infection – the typical factors are caries, cracks, fractures and breakdown of a restoration in the tooth so these should all be removed prior to endodontic treatment;[66]
- an adequate interim restoration must be placed to stabilize the tooth, to ensure no bacterial penetration can occur between appointments and after the root filling has been completed, and to avoid any irritation of the periodontal tissues;[67] and
- it is essential to ensure disinfection of the root canal system prior to placing a root canal filling through the use of adequate mechanical debridement of the canals, irrigation with antiseptic cleansing and solvent solutions, and appropriate intracanal medication between appointments.[42,43]

If there is any doubt about the long-term prognosis of a tooth with a draining sinus that is masquerading as a periodontal pocket, then a series of long-term intracanal dressings can be utilized (as outlined below) whilst the healing response is monitored.[11,43] Once the healing response and prognosis have been assessed as being adequate, then the root canal filling can be completed.

Management strategies for concurrent endodontic and periodontal diseases

Treatment of teeth with concurrent endodontic and periodontal diseases must address both of the concurrent problems. However, some debate exists within the dental literature as to which problem should be treated first.[11] The answer to this question partly relies on the diagnosis for each particular case since any acute problems (such as pain or swelling) must be treated first in order to comfort and stabilize the patient.[11] Hence, if the patient presents with an acute apical abscess, then endodontic treatment should be commenced immediately. However, if the patient presents with an acute periodontal abscess, then periodontal treatment should be commenced immediately. Once the initial treatment has been provided, the disease that was causing the acute problem will essentially return to a chronic state until further treatment results in complete healing – such further treatment should follow the guidelines listed below. However, most patients with concurrent endodontic and periodontal diseases do not have any symptoms since these conditions are typically chronic in nature. In such cases, the following treatment guidelines should be followed.

Concurrent endodontic and periodontal diseases without communication

Ideally, conventional endodontic treatment should be carried out prior to any periodontal treatment of a tooth that has both endodontic and periodontal diseases without any obvious communication between the disease processes (Fig 7).[11] The root canals should be thoroughly cleaned, irrigated and medicated before placing a root canal filling, and with all endodontic treatment being provided under aseptic conditions. The tooth should then be adequately restored to prevent further bacterial penetration from the oral cavity into the tooth and root canal system. The restoration should also provide correct contours without overhangs and food pack areas which can complicate the periodontal treatment and healing response. The periodontal treatment should be deferred until the root canal system is free of bacteria since the presence of bacteria in the root canal system will affect the outcome of the periodontal treatment in several ways. Periodontal treatment will

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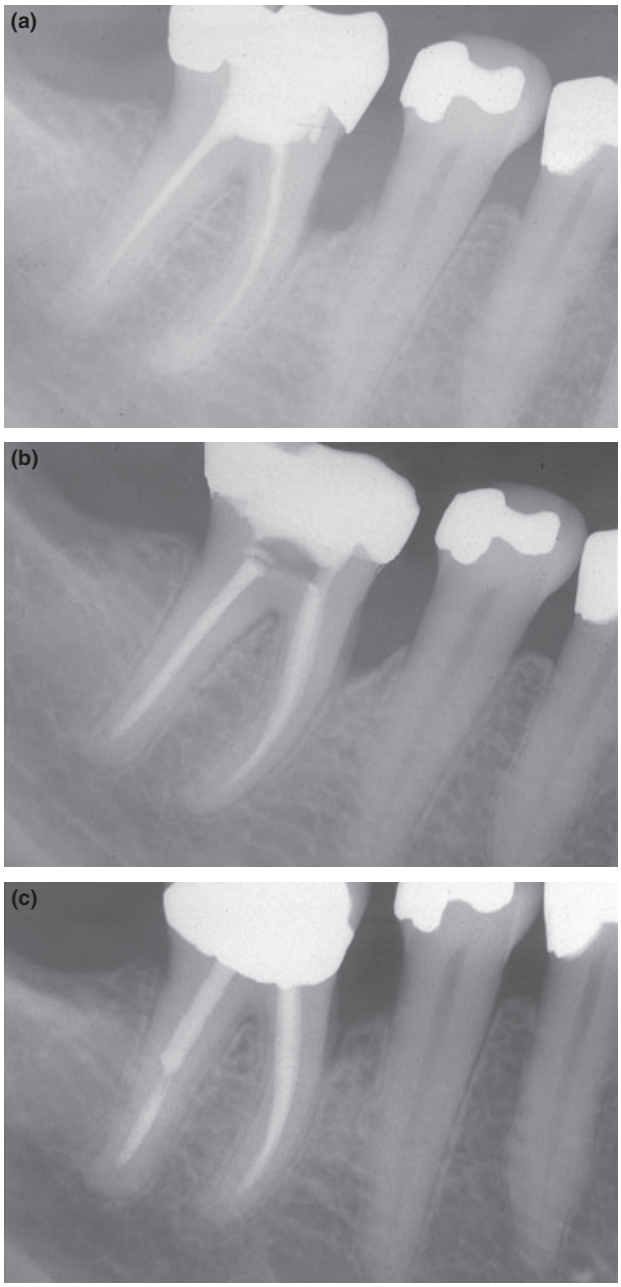

Fig 7. Management of a lower right first molar tooth with concurrent endodontic and periodontal diseases that did not communicate. The root canal system was infected with chronic apical periodontitis as a result of breakdown of the crown restoration. The tooth also had a deep periodontal pocket with significant loss of crestal bone height on the mesial and buccal aspects. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*). (a) The pre-operative radiograph shows that the existing root canal filling is technically unsatisfactory, based on radiographic appearance. The mesial food pack problem is a likely contributing factor to the periodontal pocketing in this area. (b) Periapical radiograph taken after placement of a new root canal filling after endodontic re-treatment of the tooth. This treatment involved removal of the crown, the amalgam core restoration and the root canal filling flowed by medicating the root canals and constructing an interim restoration with a stainless steel orthodontic band and a glass ionomer cement. The canals were further cleaned, prepared, irrigated and medicated over a three-month period. After the root filling was completed, the patient was referred back to his general dentist who provided routine conservative periodontal treatment to the tooth by root planing, curettage and oral hygiene instructions. The dentist also replaced the interim restoration with a new core restoration which remained in place while the periodontal treatment was done. (c) Periapical radiograph taken three years after the new root canal filling was completed. Good periapical bone repair is evident along with excellent bone repair in the mesial periodontal defect. There were no clinical signs of periodontal pocketing and the tooth has been restored with a new full coverage crown. This tooth now has a good prognosis provided the patient maintains excellent oral hygiene in this area.

remove some cementum from the root surface to expose dentinal tubules which will allow bacteria and/or their endotoxins to diffuse through the dentine to the periodontal tissues – this delays periodontal healing and may lead to external inflammatory root resorption.[33–35] Endodontic infections also stimulate the downgrowth of epithelium along denuded dentine surfaces with marginal communication,[27] amplify marginal bone loss and deepen periodontal pockets on instrumented root surfaces although teeth with gingival recession are at less risk of these problems occurring.[28,29,31,32] Hence, the ideal order of treatment is root canal treatment first followed by periodontal treatment soon after.

Concurrent endodontic and periodontal diseases with communication

Teeth that have concurrent endodontic and periodontal diseases that obviously communicate with each other will require comprehensive treatment with both endodontic and periodontal management.[11] Ideally, they should be managed concurrently (Figs 8–9) although in planned and sequenced stages to reduce possible complications from one disease entity (i.e., infection) affecting the outcome of the treatment of the other problem. That is, ideally both infections should be removed before the root canal filling and any final restorations are provided.[11] The general sequence of treatment is the same as that outlined above for concurrent diseases without communication except that completion of the root canal filling should be delayed until the periodontal prognosis has been reassessed and determined following initial, and often further, periodontal treatment.[11] Hence, the recommended approach to managing such cases is to:

(1) Commence the endodontic treatment first using the following protocol:

- under rubber dam isolation, remove all existing restorations, caries and any cracks in the tooth to allow thorough assessment of the suitability of the tooth for further restoration. If the tooth is suitable, then continue the endodontic treatment as outlined below. If the tooth is not suitable, then it should be extracted at this stage;

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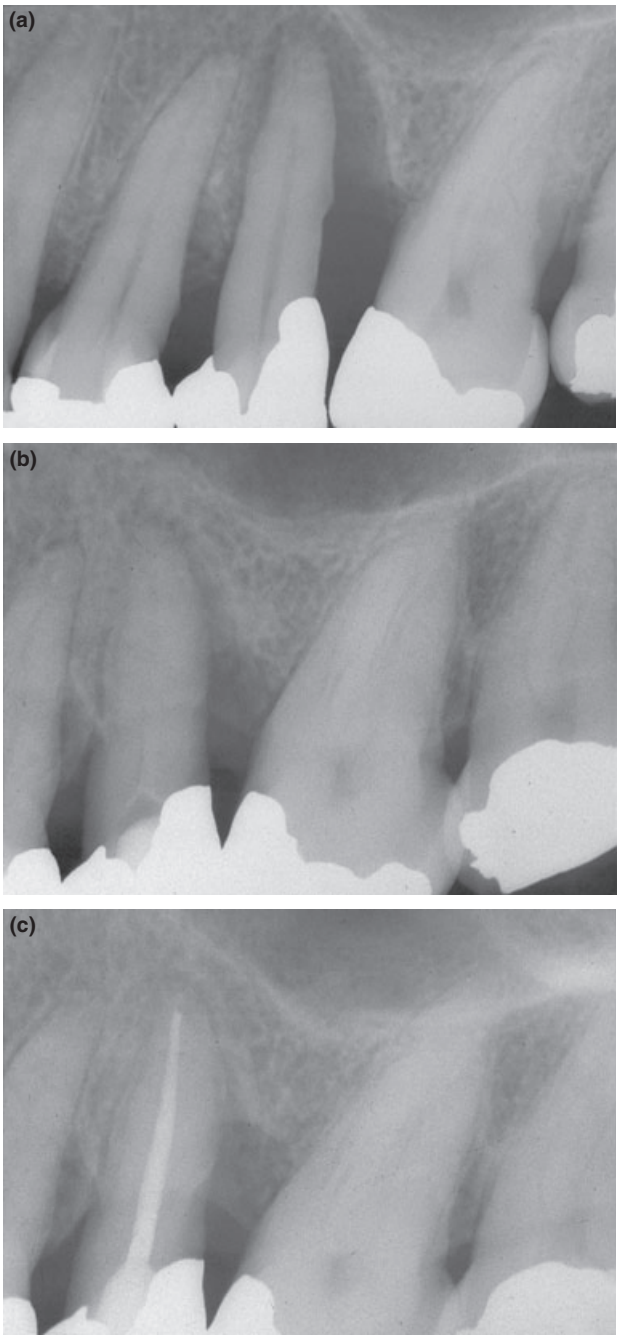

Fig 8. Management of an upper left second premolar tooth with concurrent endodontic and periodontal diseases that communicated with each other. The tooth had a pulpless, infected root canal system with chronic apical periodontitis as a result of breakdown of the coronal restoration. It also had a deep periodontal pocket on the distal aspect. The patient also had generalized periodontal disease. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*.) (a) The pre-operative radiograph shows a very deep metallic restoration and a periapical radiolucency communicating with the distal periodontal pocket. There has been marked bone loss on the distal aspect. The radiograph also suggests that there is no contact point between this tooth and the first molar tooth, and hence food packing may have been a contributory factor to both the periodontal and endodontic problems. (b) Periapical radiograph taken two months after treatment was commenced. The root canal system was cleaned and medicated, followed by initial root planing and oral hygiene instruction. At this stage, some periapical bone repair is evident but there is still some distal periodontal pocketing so further periodontal treatment and re-dressing of the canal were indicated. (c) Periapical radiograph taken at the time of placing the root canal filling which was done six months after the initiation of endodontic treatment. Intracanal medications were utilized while the periodontal treatment was provided. The periodontal treatment initially involved root planing and oral hygiene instruction. After three months, periodontal access surgery was performed in order to facilitate further root planing. At this stage, periapical bone repair is evident as well as bone repair within the distal periodontal pocket.

- thoroughly prepare, clean and irrigate the root canal system to help reduce the number of viable bacteria within the root canal system;
- place Ledermix paste as an initial medicament to control any symptoms, to reduce the intracanal infection, to reduce the periapical inflammatory response[42,43] and to arrest any external inflammatory root resorption[56,57] which may be present in up to 80 per cent of teeth with apical periodontitis;[68]
- construct an interim restoration (e.g., by using glass ionomer cement with or without a stainless steel band, as required);[67] the interim restoration must not complicate the periodontal status, it must not restrict access for the periodontal treatment, and it must not affect the patient's ability to clean the tooth;
- change the intracanal medicament after four weeks to a 50:50 mixture of Ledermix paste and a calcium hydroxide paste such as Pulpdent paste (Pulpdent Corporation, Watertown, MA, USA).[42,43]

(2) Commence periodontal treatment once the second dressing has been placed. The concept is to provide the initial periodontal treatment while the root canals are still medicated since this creates the most unfavourable environment for bacterial survival. Typically, non-surgical root planing and oral hygiene instructions are sufficient for the initial periodontal management although some cases may need surgical access for adequate root planing and cleaning at this stage.

(3) Three months later, the periodontal healing response should be reassessed. If the response has been favourable, then the root canal filling can be placed followed by a suitable coronal restoration. The patient should then be re-appointed for ongoing periodontal maintenance and to review the periapical healing response on a regular basis. Such cases usually have a reasonable prognosis (see below).

(4) Alternatively, if the initial periodontal response has not been favourable or is not ideal at the three-month review, then the root canal system should be re-medicated with a fresh mixture of Ledermix and Pulpdent pastes and then further periodontal treatment – such as more root planing and/or periodontal

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Fig 9. Management of an upper left first molar with concurrent endodontic and periodontal diseases that communicated with each other. The tooth had a pulpless, infected root canal system with chronic apical periodontitis as a result of breakdown of the coronal restoration. It also had a deep periodontal pocket on the mesial aspect. The patient was diabetic and had generalized periodontal disease. (Reproduced with permission and courtesy of the *Journal of the New Zealand Society of Periodontology*.) (a) The pre-operative radiograph showed marked bone loss associated with the mesio-buccal root and extending to the periapical region of this root. (b) Periapical radiograph taken immediately after placing the root canal filling which was done seven months after the initiation of endodontic treatment. The canals were medicated throughout this time while the periodontal treatment was provided. Initial root planing was followed by periodontal access surgery to allow better cleaning and to apically reposition the gingival margin. There is evidence of mesial and periapical bone repair at this stage. (c) Clinical appearance at the time of completing the root canal filling and after the periodontal surgery had been done. There has been some gingival recession as a result of the periodontal disease and treatment, especially following apical repositioning of the flap during surgery. (d) A review radiograph taken six months after completion of the root canal filling shows further bone repair on the mesial aspect. There was no periodontal pocketing present and the tooth had no signs of active periodontal disease. (e) A review radiograph taken 10 years after endodontic and periodontal treatment shows no progression of the periodontal disease and no further bone loss on the mesial aspect. Periodontal probing depths on the mesial aspect were approximately 3 mm and there was only slight bleeding on probing.

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flap surgery – should be arranged as soon as possible. Following such further periodontal treatment, the tooth should be reviewed again after another three months to reassess the healing response and to determine whether the prognosis has improved sufficiently to justify any further treatment.

- If the healing has been adequate and the prognosis has improved at that stage, then the root canal filling can be completed and the coronal restoration can be placed; this should then be followed by ongoing reviews and periodontal maintenance therapy as described above.
- On the other hand, if the response to the further periodontal treatment has not been favourable, then the root canals should be re-medicated at three-monthly intervals to allow further periodontal assessment and treatment to be provided. Alternatively, if the periodontal prognosis is deemed to be poor at this stage, then extraction should be considered. Some teeth may be suitable for procedures such as root resection or hemisection, in which case the root canal filling should be completed immediately prior to these procedures being performed.

(5) In general and wherever possible, once the root canal filling has been completed, full coverage cast crowns should be deferred until after further reviews have confirmed that the prognosis of the tooth and its periodontal condition justify such complex and costly restorative dental treatment. As an example, an amalgam core restoration with cusp overlay can be used during this period of further reassessment.

Prognosis

The prognosis of teeth with concurrent endodontic and periodontal diseases will initially be difficult to determine in most cases prior to treatment, especially in those teeth where the diseases communicate with each other. Therefore, it is essential to continually reassess the prognosis after each phase of treatment and after appropriate time intervals to allow healing and stabilization of the tissues. The prognosis will depend on many factors,[11] some of which are:

- the primary cause of the diseases
- the amount of attachment loss prior to treatment
- the patient's healing responses
- effectiveness of oral hygiene procedures used by the patient
- the patient compliance with seeking maintenance therapy
- the effectiveness of maintenance therapy, and
- the longevity of any restorations.

In general, the periodontal prognosis and the effectiveness of the patient's oral hygiene procedures will be the main determinants of the prognosis and the overall treatment outcomes. The prognosis will usually be better if the endodontic and periodontal diseases do not communicate since they are effectively independent diseases and the periodontal pocket is not as deep as when the diseases communicate.[11]

Concurrent diseases that communicate have the worst prognosis and are therefore more likely to require further treatment. However, it is again emphasized that the prognosis cannot be easily determined until after initial endodontic and periodontal treatment have been provided. Any further proposed treatment must consider the effectiveness of the patient's oral hygiene procedures and the concurrent nature of the disease processes. The prognosis of further treatment will also be difficult to predict because of the multi-factorial nature of the diseases.

Since the long-term prognosis cannot always be readily assessed prior to treatment, it is important that teeth are not quickly condemned for extraction and that all treatment options are considered. Generally, it is better to provide the appropriate initial phases of treatment (e.g., root canal cleaning and medication plus root planing) before making any definite recommendations to the patient about other procedures, especially surgery or extraction. Many teeth can be saved with good quality care and with regular professional maintenance but, as with all aspects of periodontal disease, the patient must carry out meticulous oral hygiene procedures in the area in order to keep the tooth free of plaque and calculus.

CONCLUSIONS

Endodontic and periodontal diseases can provide many challenges to clinicians. Although there may be difficulties in establishing a correct diagnosis, this is the most important phase of their management as the diagnosis will determine the type and sequence of treatment required. In general, if the root canal system is infected, endodontic treatment should be commenced prior to any periodontal therapy in order to remove the intracanal infection before any cementum is removed. This avoids several complications and provides a favourable situation for tissue repair. The endodontic treatment can be completed before periodontal treatment is provided except where there is a ''concurrent endodontic and periodontal lesion with communication'' – in these cases, the root canals should be medicated until the periodontal treatment has been completed and the overall prognosis has been reassessed as being favourable. The use of non-toxic intracanal therapeutic medicaments is essential to destroy bacteria and to encourage tissue healing.

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