

Resorption: part 2. Diagnosis and management

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VERIFIABLE CPD PAPER

IN BRIEF

- Provides an overview of the clinical indicators of root resorption.
- Explains the role of modern imaging in classifying resorptive lesions.
- Discusses the management of resorption considering classification and aetiology.
- Provides algorithms for practitioners to follow when considering the diagnosis and management of resorption.

PRACTICE

In this second paper the clinical indicators of root resorption and their diagnosis and management are considered. While the clinical picture can be similar, pathological processes of resorption vary greatly from site to site and this paper proposes appropriate approaches to treatment for teeth that are affected by resorption.

INTRODUCTION

Root resorption has been defined as the loss of dental hard tissue as a result of osteoclastic cell action¹ and can occur on both external and internal surfaces. The process can be self limiting and is often sub-clinical as seen in the case of surface resorption.² It can, however, be more progressive and potentially destructive.² The resorptive process has been classified as being internal or external to the tooth with a number of sub-classifications.³ Internal resorption is inflammatory in nature but the resorptive process may have a replacement component with tissue of mixed origin being deposited within the canal.⁴ This tissue can be calcific.⁴ External root resorption can be classified as being surface, inflammatory, cervical or replacement resorption.² Although the clinical picture may be similar and any difference appears only to be related to the site of resorption, the pathological processes are somewhat different and thus demand different treatment protocols. Accurate and early diagnosis of resorption is critical for successful treatment. This paper considers diagnosis and proposes appropriate

approaches to treatment for teeth that are affected by resorption.

DIAGNOSIS

History

Diagnosis should be based upon a sound clinical history. Teeth affected by resorption lesions are often asymptomatic and may present as an incidental finding upon radiographic examination so it is essential that the clinician should pay particular attention to aspects of the history that may play a role in the development of resorption.

These factors include:

- History of trauma^{3,5}
- History of crown preparation⁶
- History of pulpotomy⁶
- Orthodontic history^{7,8}
- Use of intra-pulpal chemicals such as internal bleaching products⁹⁻¹¹
- History of removal of impacted teeth^{12,13}
- History of surgical procedures in proximity to the affected roots
- History of periodontal disease and its management^{14,15}
- In more extensive resorptive conditions involving multiple teeth it may be of interest to discuss if the patient has any contacts with cats (see below).¹⁶

For a more extensive review of possible aetiological factors that may be elicited from the history the reader should refer to the first of these papers.¹⁷



Fig. 1 Evident discoloration of the crown with darkening of the cervical portion post trauma. This was diagnosed as ERR

Clinical examination

Full extra and intra oral clinical examinations should be performed before more specific investigations of the relevant teeth are carried out. The colour of the tooth should be noted with specific reference to precise site of any discoloration (Fig. 1). In the cervical portion of the teeth pinkish colouration is indicative of resorption. The presence of all restorations should be recorded and note made of primary disease, leaking margins and recurrent caries. The use of percussion is of relevance in resorption cases and thus should be noted and compared to adjacent teeth: a metallic sound may suggest a diagnosis of ankylosis. An increase in mobility may indicate attachment loss or pathological fracture due to extensive external resorption. This should be compared by recording the mobility of the adjacent teeth. A complete loss of physiological mobility may also indicate an ankylosed tooth. After a basic periodontal examination has been recorded, note should be made of any pocketing in relation to the teeth under investigation. Subgingival cavities

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may be noted on pocket charting. These should be probed and the nature of the cavities described.

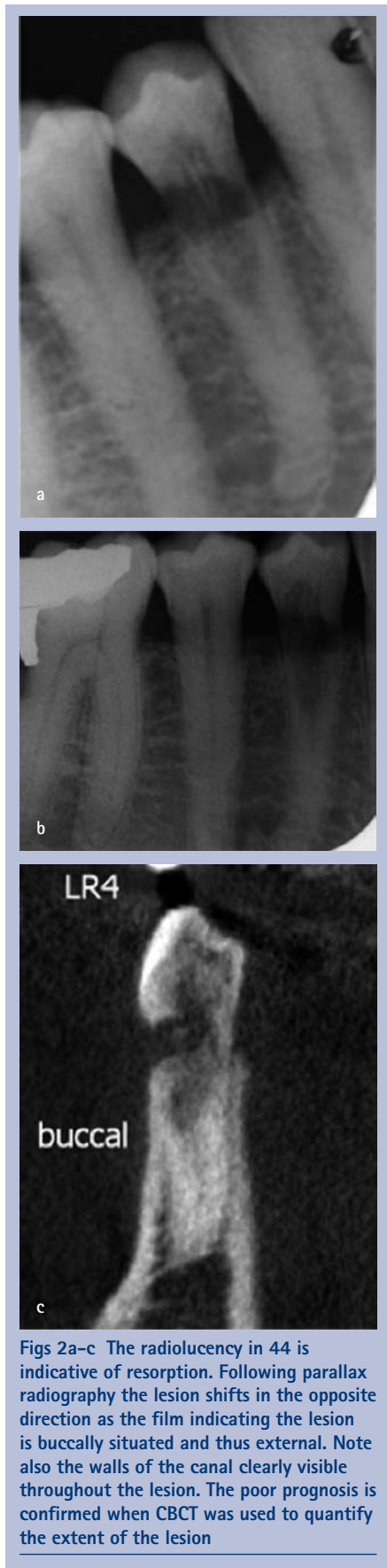
Radiographic examination

If resorption is suspected one or more periapical radiographs should be taken. Panorals do not provide sufficient detail for the diagnosis of smaller lesions.¹⁸ Parallax radiographs should be considered as this technique will yield further information about the site and type of lesion. Using the ‘same lingual, opposite buccal rule’ (SLOB) the shift of an external lesion can be detected. Internal lesions, however, should remain in a similar position relative to the root canal (Figs 2a-c).¹⁹

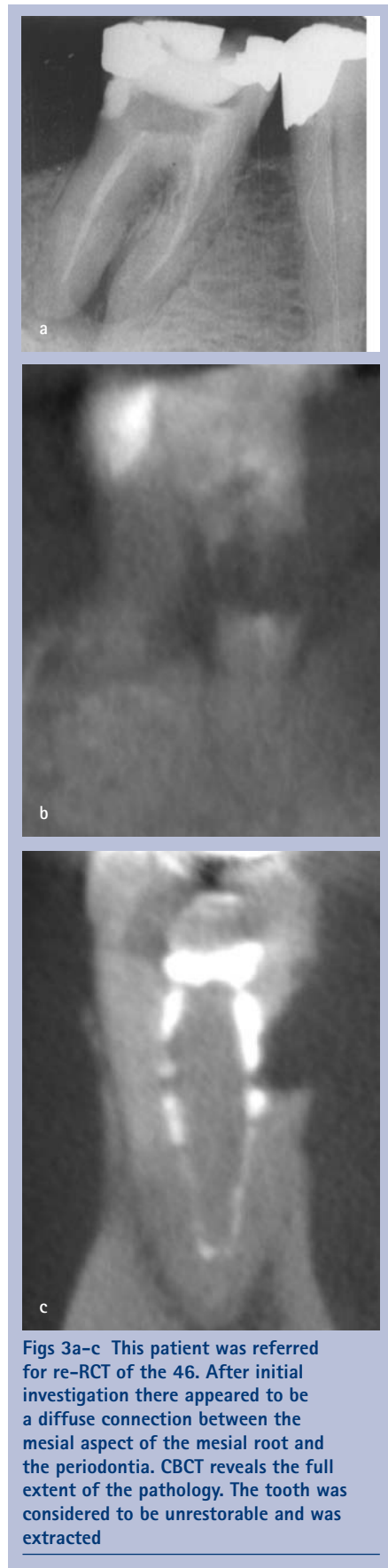
The limitations of routine dental radiography are widely known.²⁰⁻²² Superimposition of anatomical features, inadvertent distortion when film holders are used and the two-dimensional nature of the image may result in a less than ideal image. Furthermore, it has been demonstrated that radiographs may not be sufficiently sensitive to enable diagnosis of external resorptive lesions.¹⁸ The size of the lesion, its location, local anatomy and bone density have all been demonstrated to influence the detection of lesions.²³⁻²⁵ Small resorptive cavities and those present on buccal and lingual surfaces are more likely to remain undiagnosed.^{23,25,26} Significant differences in inter and intra-rater detection of resorption have been demonstrated.^{27,28} Thus clinicians should be aware of these limitations, examine radiographs under appropriate conditions and refer for an opinion for further imaging if in doubt.

Cone beam computed tomography (CBCT)

A number of case reports have demonstrated that CBCT can enhance the diagnosis of resorptive lesions.²⁹⁻³¹ These have been further supported by clinical studies though most are *in vitro*.³²⁻³⁴ The one *in vivo* study had a small sample size.²² The use of CBCT enables the precise determination of site, type and extent of the lesion. There has been an increase in the number of publications related to the use of CBCT for diagnosis of both internal and external lesions although many are case reports.^{30,35-37} Most clinical studies are related to artificially generated root lesions.^{34,38,39} Nonetheless



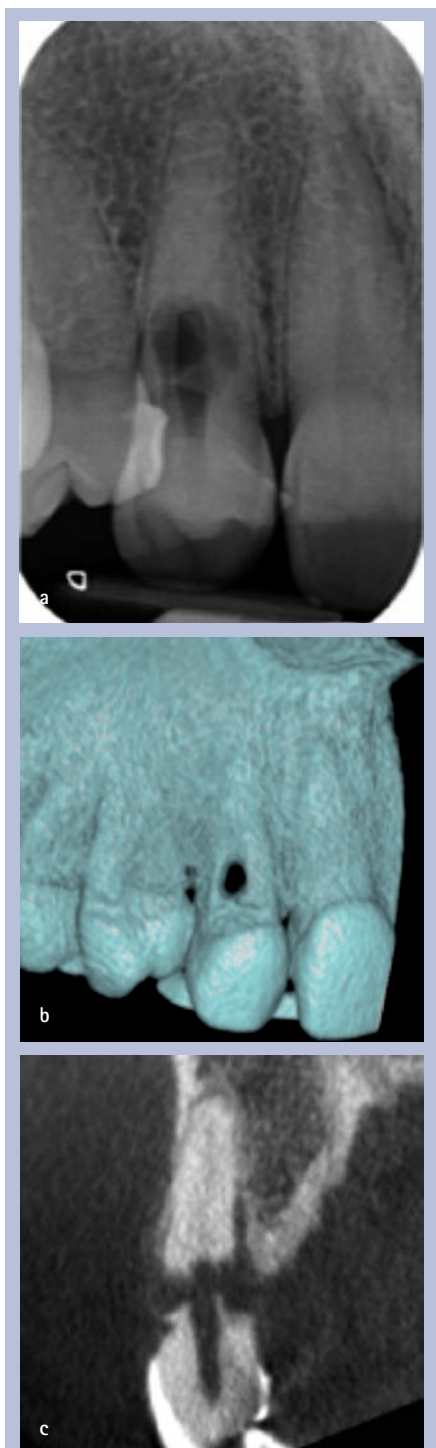
Figs 2a-c The radiolucency in 44 is indicative of resorption. Following parallax radiography the lesion shifts in the opposite direction as the film indicating the lesion is buccally situated and thus external. Note also the walls of the canal clearly visible throughout the lesion. The poor prognosis is confirmed when CBCT was used to quantify the extent of the lesion



Figs 3a-c This patient was referred for re-RCT of the 46. After initial investigation there appeared to be a diffuse connection between the mesial aspect of the mesial root and the periodontia. CBCT reveals the full extent of the pathology. The tooth was considered to be unrestorable and was extracted

the indications are that CBCT is of value in the diagnosis, and ultimately the management of resorption (Figs 3a-c and 4a-c).²² As exposure to ionizing radiation must

be kept to a minimum, referral for CBCT should only be made if it will be of significant assistance in diagnosis or management. Figure 5 presents a simple algorithm



Figs 4a–c This lesion presented as an incidental finding. A preliminary diagnosis was made of external cervical resorption. The depth of radiolucency of the mid/coronal third indicates an extensive lesion. CBCT reveals the true extent of the lesion

that may be used to help classify lesions radiographically and indicates when CBCT may be of value.

For further information upon the use of CBCT in dentistry readers are directed towards the European guidelines on dental CBCT at http://ec.europa.eu/energy/nuclear/radiation_protection/doc/

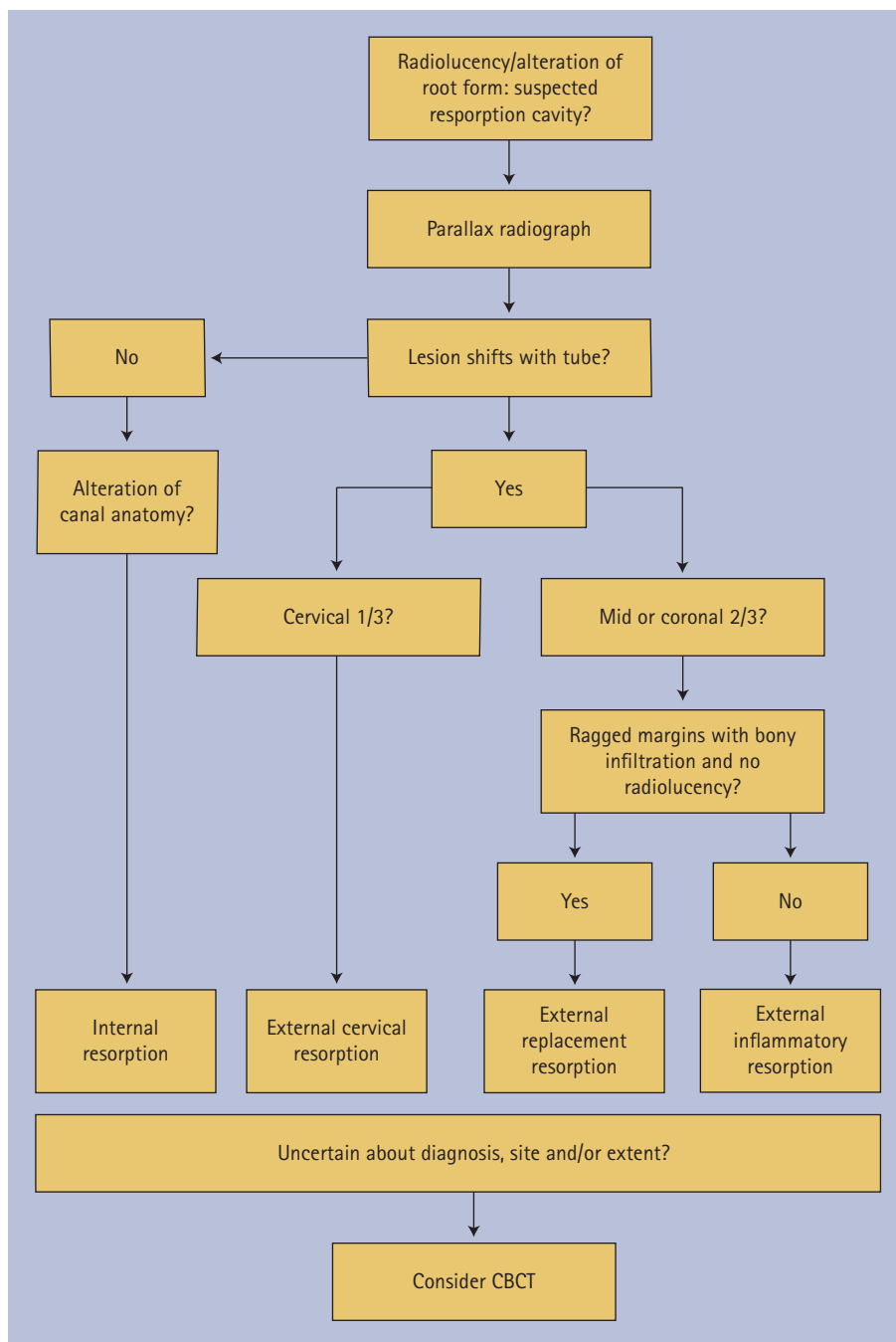


Fig. 5 A flow diagram to aid radiographic diagnosis of resorption

publication/172.pdf. This comprehensive report reviews the current evidence pertaining to the use of CBCT in dental and maxillofacial imaging and provides evidence-based guidelines for clinicians using or seeking to use CBCT as a diagnostic and treatment planning aid.

At this point the clinician may have come to a reasonably accurate diagnosis, although not necessarily the extent of the lesion or the possible management options. In order that resorption can be accurately diagnosed and classified careful examination and use of any appropriate special tests are essential. Each type of lesion

bears certain characteristics and it is only following accurate diagnosis that the correct form of treatment can be instigated.

In the following section different forms of resorption are considered.

External surface resorption

Surface resorption is usually sub-clinical. Radiographically it may be seen as cavitation in the cementum and dentine, or an alteration of the root contour.⁴⁰ There is no corresponding inflammatory response in the periodontal ligament and there is no destruction of adjacent alveolar bone.⁴¹ This type of resorption is self limiting

and, if diagnosed, no further treatment is necessary.⁴⁰

External inflammatory resorption

External root resorption is often sub-clinical unless there is an acute inflammatory process and the tooth becomes tender to pressure or there is an associated swelling or the reduced support leads to mobility. The resorptive lesion is often an incidental radiographic finding. Presentation will vary depending upon whether the process is infective or sterile.

Sterile inflammatory resorption

Associated with pressure including orthodontics, impacted teeth etc (Figs 6a and b), radiographic evidence of causative pathology such as ectopic tooth/ bony pathology and radiographic shortening and blunting of the root apices related to the upper anterior teeth.⁴² The extent of the shortening is variable but the apices are classically rounded. These teeth usually give a positive response to vitality testing. If there is a history of trauma, the extent of the resorption may be more extensive and there may be a loss of vitality. If there is a superimposed infective process the resorption may be far more aggressive with more extensive and irregular root destruction.

Infective inflammatory resorption

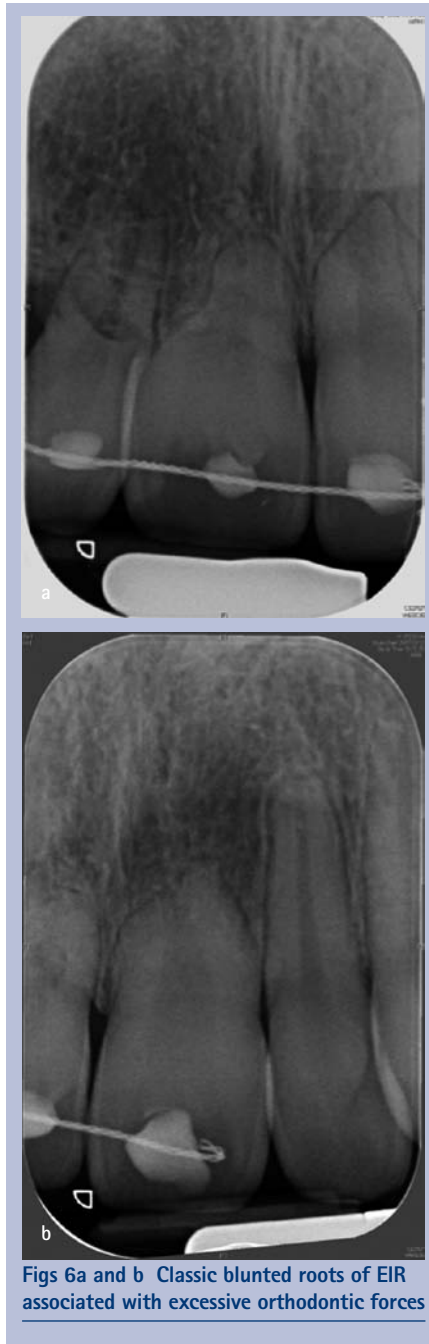
Associated with trauma and/or pulpal necrosis (Figs 7a, b and 8). The canal can often be visualised radiographically.¹⁹ When the process is related to an endodontic stimulus alone the resorptive area is associated primarily with the apex or a lateral canal or both.

Associated with radiographic irregular concavity/concavities; bowl shaped resorption of the root and a corresponding radiolucency in the bone.⁴³ May appear moth-eaten.

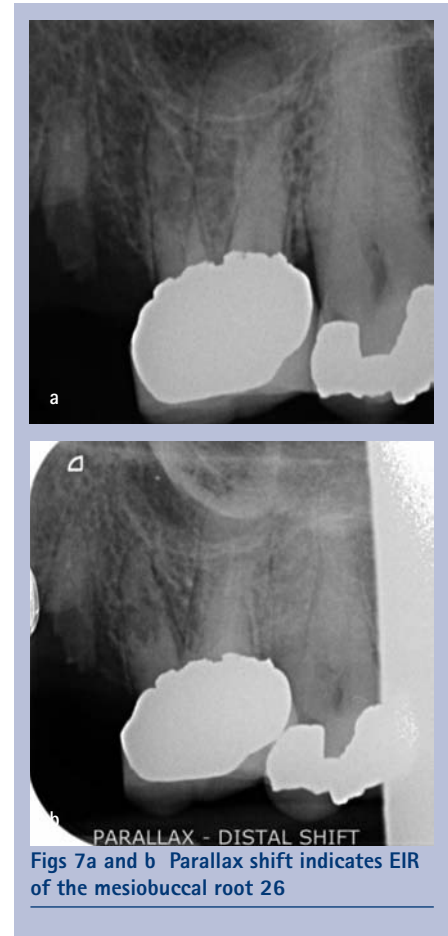
In the mildest form there may simply be a local loss of architecture but in severe forms there can be extensive loss of hard tissue.

In avulsion injuries the site may be potentially anywhere at which the periodontal ligament and the cementum have been damaged due to the trauma or via adverse environmental conditions such as dehydration if inappropriately stored.

These teeth will give a negative response to vitality testing.⁶



Figs 6a and b Classic blunted roots of EIR associated with excessive orthodontic forces



Figs 7a and b Parallax shift indicates EIR of the mesiobuccal root 26

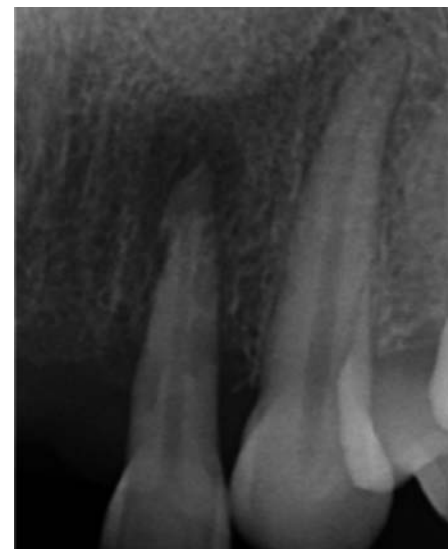
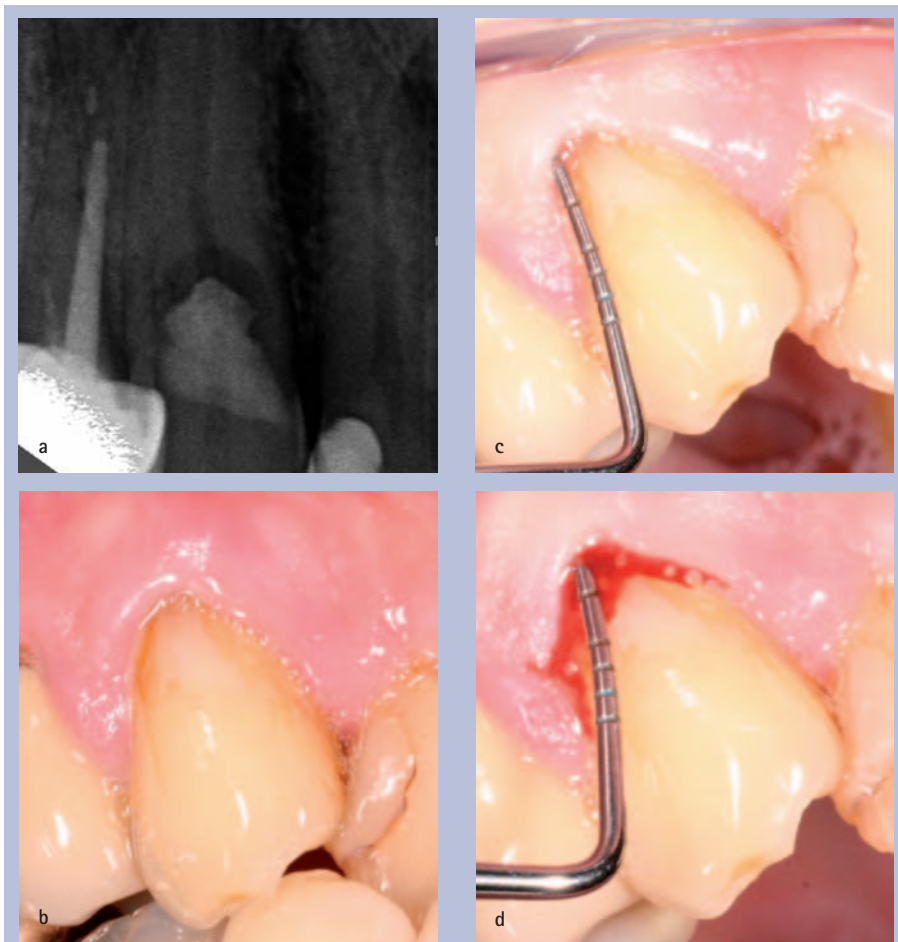


Fig. 8 Bowl shaped resorption of the 22 with corresponding radiolucency post trauma. This is indicative of EIR

External cervical resorption

Resorptive lesions on the external cervical aspect of the tooth are often symptomless though there may be a sensation of mild discomfort or irritation from the surrounding gingival tissues.⁴⁴ Initially there would not be pulpal involvement⁴⁵ but if the lesion is significantly advanced there may be pulpitic symptoms as a communication with the pulp may ensue.⁴ Thus pulpitic symptoms may arise and these may precede those of periapical disease. Clinically, it may be that cervical resorption is only detected when the lesion is in close proximity to the crown (Figs 9a-d). Other signs of external cervical resorption:

- The cervical enamel and root surface may appear to be pink due to vascular granulation tissue within the resorptive cavity.¹
- Probing may elicit profuse bleeding⁴⁶
- The edges of the cavity may be palpated as being sharp and thinned
- Probing of the cavity reveals a hard, rough surface and distinguishes



Figs 9a–d ECR 13: cervical radiolucency, a hard cavity on probing and extensive bleeding. This lesion had been accessed and restoration attempted by the GDP but the cavity had not been thoroughly curetted and restored

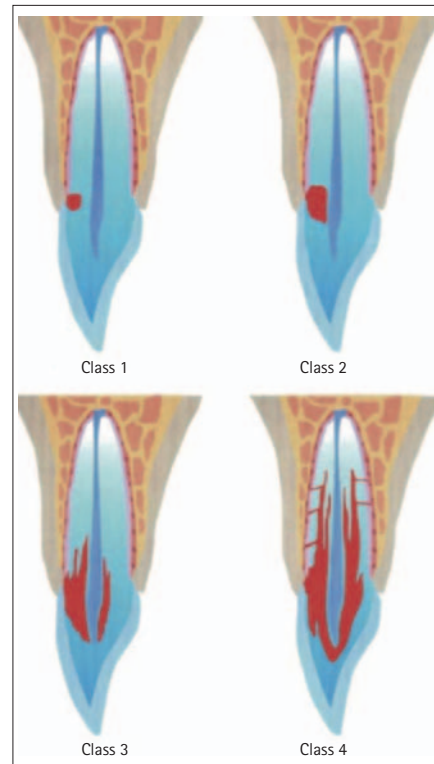


Fig. 10 Heithersay's classification of cervical resorption⁵¹



Figs 11a and b ECR on the lingual aspect of the 31. The lesion approaches but does not encircle the pulp: Heithersay Class 2 ECR

resorption from caries⁴⁷

- A purulent exudate indicates a superimposed infective process
- Unless the lesion is very extensive, the tooth will be positive to vitality testing as the pulp will not be involved
- Mobility of the coronal portion may be indicative of a pathological fracture.

Diagnosis can be problematic if the cavity cannot be visualised and assessed easily intra-orally. In such cases, external cervical resorption is notoriously difficult to distinguish from internal resorptive lesions.^{44,48} Both may present with a 'pink spot' though the origin and histopathology of these varies. Differentiation between the two is largely based upon radiographic examination using the parallax technique. Radiographically features may include:

- Asymmetric irregular radiolucency in the cervical region of the root
- Possible corresponding loss of alveolar bone⁴⁹
- Interproximal lesions may be

diagnosed more readily and thus earlier but care should be taken to differentiate these from cervical burnout on radiographs

- The periphery of the lesion may be irregular and appear to be superimposed upon the outline of the pulp cavity⁵⁰
- In more advanced cases the lesion may be multilocular and mottled if these is fibro-osseous tissue in the cavity⁵⁰
- The root canal may reveal a loss of radiographic continuity in advanced disease.

Conventional radiography does not allow for three dimensional imaging and assessment of ECR lesions.³¹ As such CBCT is a valuable diagnostic aid and offers the potential for accurate assessment of the extent of the lesion and aids treatment planning.^{21,30,31}

Heithersay subdivided cervical resorptive lesions into four categories (Fig. 10):⁵¹

- Class 1 lesions just penetrate the root dentine of the cervical area

- Class 2 lesions are deeper and in closer proximity to the pulp but remain within coronal dentine (Figs 11a and b)
- Class 3 lesions are more extensive and involve the coronal third of the root. (Figs 12a and b)
- Class 4 lesions extend into the coronal half of the root dentine and may completely envelop the pulp: there is a possibility of pulpal involvement (Fig. 13).

If three or more teeth show signs of resorption and there is no clear cause factor a diagnosis of multiple idiopathic resorption should be considered. (Figs 14a and b)

External replacement resorption

There are often **no symptoms** associated with external replacement resorption (ERR)⁵² but there may be **clinical signs when 10-20%** of the root is affected.⁵³ There are three significant clinical manifestations of ERR:

- A change in percussive sound; the tooth will have a **high pitched or metallic sound to percussion**.^{53,54} Simple percussion with the handle of a dental mirror has been demonstrated as a reliable method of diagnosing ERR⁵⁵
- A **lack of mobility**.^{53,54} Classically this can be assessed with manual palpation of the tooth in a labio-lingual direction and use of the Miller index.⁵⁶ Electronic gauges such as **Periotest** may be used but the results must be interpreted with caution⁵⁷ and a diagnosis made only after corroboration with other signs and symptoms⁵⁵
- The tooth may be **infra-occlusion**.^{53,58} This will be more severe if the ERR began before the age of 10 years, less severe in the 12-16 year age range and may be minimal if it occurs after pubertal growth and in adulthood.⁵⁹

In the early stages of ERR there may be minimal or no evidence on radiographs.⁵⁶ With conventional two dimensional radiography if the ERR is occurring on the labial or lingual surfaces it will not be readily visible.^{60,61} In more advanced lesions there is complete or partial loss of the lamina dura and, depending upon



Figs 12a and b In this image the lesion it is possible to trace the dentinal borders of the root canal and therefore it is most likely an external cervical lesion. Supplemental CBCT supports this: Heithersay Class 3 ECR

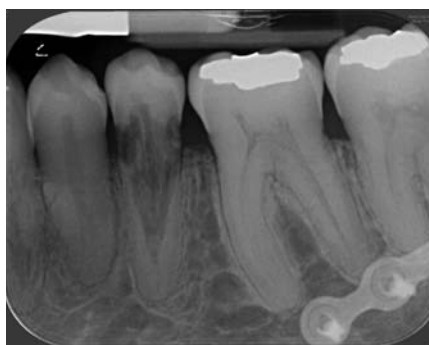


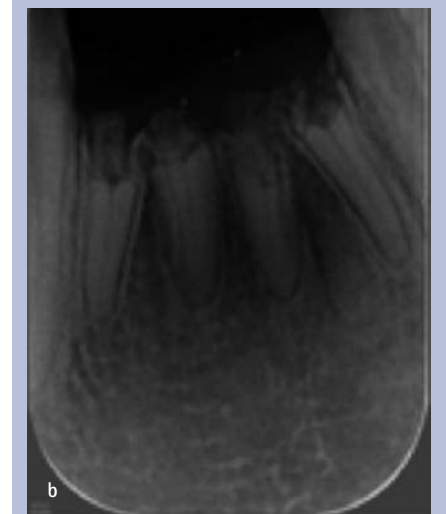
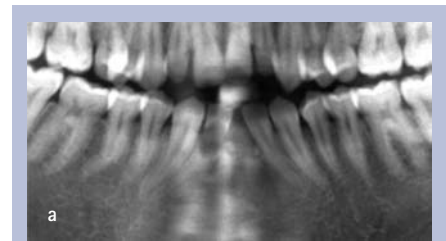
Fig. 13 Heithersay Class 4 ECR of the 35

the extent of the process, the root dentine will appear either irregular or completely 'moth-eaten' as bone progressively replaces dentine. There is an absence of radiolucency (Fig. 15)⁴³

Internal inflammatory resorption

The tooth may have a history of trauma, vital pulp therapy or crown preparation.⁶

Internal resorption may present as the original characteristic 'pink spot' or **Mummy tooth**.⁶² The clastic activity



Figs 14a and b These two radiographs are of the same patient in 2008 and 2011. In the panoramic radiograph of 2008 the retained roots of the lower central incisors are evident and there is a large resorptive cavity in the lower left lateral incisor tooth 32. Within three years a similar lesion presented on the lower right lateral incisor and all the lower incisors suffered pathological fractures. This patient had no relevant dental history thus a diagnosis of multiple idiopathic resorption was made



Fig. 15 Direct apposition of bone on root surface, diffuse and extensive loss of root and absence of radiolucency; all indicative of ERR

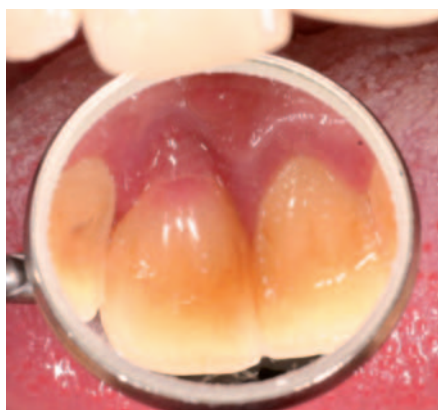


Fig. 16 Pink discoloration of coronal aspect of the UR1 root in a case of IIR

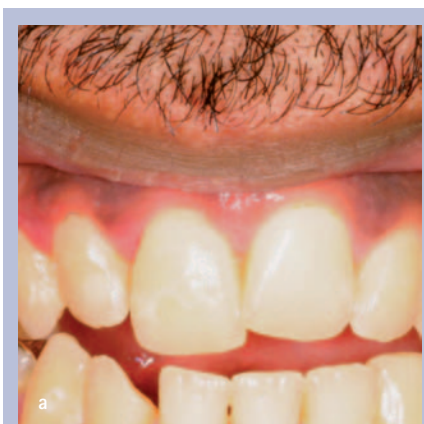


Fig. 17 CBCT of 21. The radiolucent expansion of the canal in the apical third is typical of internal resorption

within the pulp space thins the dentine to the point at which the granulation tissue⁶³ of the resorptive cavity lies beneath the enamel, thus the crown of the tooth may have a pinkish hue (Fig. 16).

The tooth is often partially vital and there may be the symptoms of pulpitis⁶³ though vitality testing may be inconclusive. If there is complete necrosis of the pulp the patient may develop signs and symptoms indicative of periapical periodontitis: tenderness to percussion, sinus tract development and/or acute swelling.

Radiographically there will be an oval shaped lacunae within the canal, often spreading symmetrically or eccentrically



Figs 18a and b IIR of 11. The innocuous intraoral appearance belies the true extent of pathology

(Figs 17 and 18).⁴⁹ If the lesion is not in the most apical portion of the root, it will merge with the normal canal anatomy apical to the resorptive region.⁴⁸

The margins are sharp, smooth and clearly defined and the canal will not appear present in the area of the lesion.¹⁹ As described above, paralleling technique is essential when taking radiographs.

Internal replacement resorption

Internal replacement resorption results in:

- An asymmetric and irregular enlargement of the pulp canal with distortion of the canal anatomy^{40,64}
- The canal/pulp may appear to be obliterated or replaced with a mixed radio-opaque area with loss of the root canal walls⁶³
- This may also appear as a pinkish area in the crown of the tooth

- Vitality testing may yield a positive response unless there is crown or root perforation.⁶⁵

Replacement resorption may be very difficult to distinguish from ECR.⁶³ Referral for CBCT may be appropriate if there is doubt.^{30,66}

MANAGEMENT

The fundamental principle related to management of any resorptive lesion is to halt the activity of the osteoclastic cell. This may be by: removing the source of stimulation, reducing osteoclastic activity, stimulating repair or by a combination of methods. In cases of resorption due to pressure it may be possible to remove the stimulus; for example extraction of the impacted canine or to halt active orthodontic treatment. In cases in which the stimulus is necrotic pulpal tissue and bacteria, root canal treatment is key to success. In cases in which the stimulus is damage to the periodontal ligament, cementum or pre dentine, direct management may be more difficult and treatment should be directed to influencing the osteoclastic cell behaviour.

The decision as to whether or not to treat may be difficult to make. Key considerations will be related to the degree of resorption, the activity of the lesion and the aetiology. Mild resorption related to orthodontic tooth movement for example will not require intervention other than reduction or cessation of forces yet internal resorption of any kind most certainly will.

If resorption due to an expanding lesion of unknown aetiology within the cortical bone is evident, immediate referral to the local maxillofacial department is essential. Likewise if the aetiology or extent of a resorptive process cannot be defined, referral to a specialist centre is advisable. Once a diagnosis has been made a management plan can be devised. Heithersay divided the management options for resorptive root lesions into four categories:⁵¹

- Conditions that will respond to conservative endodontic treatment
- Conditions that will require surgical endodontics
- Conditions that will require combined therapy, for example, endodontics, orthodontics, periodontics and prosthodontics
- Conditions that will not respond to or do not require any treatment.⁶⁷

Treatment should be initiated only if it will improve the prognosis of the tooth. All treatment should be performed under optimal conditions including a good light source and magnification.

External inflammatory resorption: prevention

Maintenance of vitality

Prevention of external root resorption is essential. Patients at risk of dental trauma should be provided with custom made gum shields to be worn when the risk is present.⁶⁸ Those patients with a Class II Division 1 incisor relationship should be advised about the benefits of orthodontic treatment.^{69,70} Those at risk of trauma and those who work with people at risk of trauma should be instructed in the judicious management of traumatised teeth and the optimum handling of avulsed teeth. Ideally, avulsed teeth should be immediately gently manipulated back into place.⁷¹ If replantation is not possible the tooth should be stored in a suitable medium. Sterile saline is an excellent medium but may not be readily available. Milk is often at hand, but if not, simply placing a tooth under the tongue may be adequate to reduce the drying time of the periodontal ligament and provide optimum conditions for cell survival.⁷¹ The period of time the tooth is extra-oral is critical: if the extra-oral period exceeds 90 minutes, healing is significantly lowered.⁴³

The patient should visit the dentist immediately and the tooth/teeth splinted with a functional splint for up to two weeks (Figs 19a and b).⁷¹ If there is damage to the alveolar bone the tooth may not be easily repositioned as the socket may be damaged also. Patients presenting with trauma or history of trauma to the dentition should be kept under regular clinical and radiographic review. Prescription of antibiotics is wise, especially if there has been suspected contamination of the wound or tooth at injury. Tetracycline has been recommended as the antibiotic of choice as it has substantial anti-bacterial as well as anti-resorptive properties.⁷² In addition to antibiotics, steroids have been demonstrated to have anti-resorptive properties. The routine use of Ledermix paste in the root canal has been advocated as this material contains both tetracycline and corticosteroids.⁷³ The use of Emdogain has



Figs 19a and b Traumatic loss of 11 and 12. 11 was located, replanted and functionally splinted for ten days



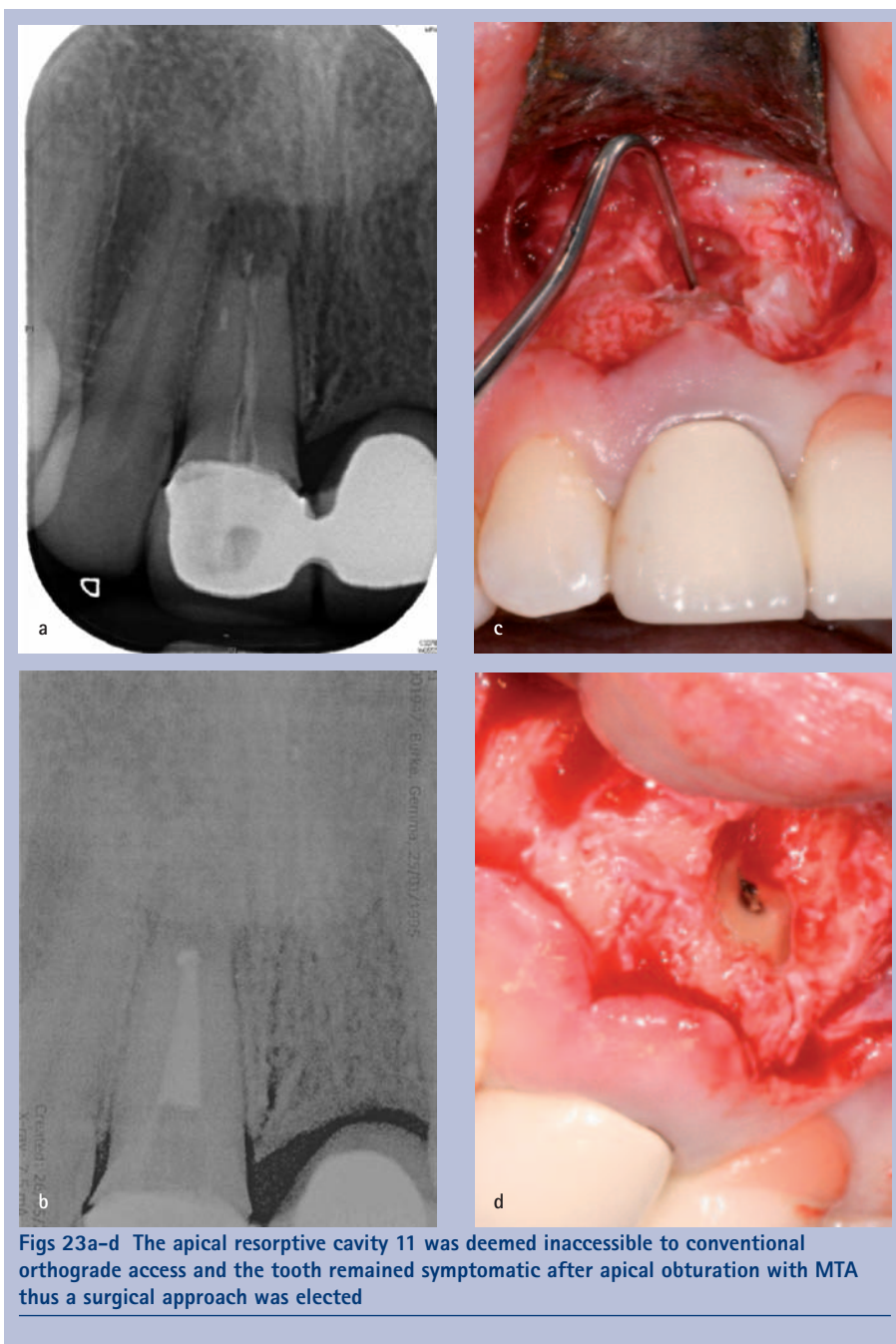
Figs 20a and b After replantation of 11 with a closed apex endodontic therapy was performed



Fig. 21 This external apical resorption was managed with routine orthograde endodontic treatment. The apical GP is over extended. This resulted from an inadequate apical stop, a common difficulty with open apices/irregular apical anatomy secondary to resorption



Figs 22a-c EIR of the distal root of 36. Endodontic therapy was initiated and the canal dressed with TG PEX. The distal root was widened coronally and an MTA plug placed. The mesial roots were cleaned, shaped and obturated by conventional means



Figs 23a–d The apical resorptive cavity 11 was deemed inaccessible to conventional orthograde access and the tooth remained symptomatic after apical obturation with MTA thus a surgical approach was elected

Traumatology guidelines published in *Dental Traumatology* in 2007.⁷¹

External inflammatory resorption: damage limitation

If resorption is diagnosed treatment must be considered: resorption may be rapid, resulting in tooth loss in as little as two months.⁴³ Management is largely based upon the aetiology: whether the process is **sterile or infective**. If the stimulus is sterile due to orthodontic tooth movement treatment should not necessarily be discontinued but the forces should be reduced. If resorption is due to stimulation from an infective process the stimulus should be halted and orthograde endodontics is the treatment of choice. Endodontic therapy undertaken to a high standard results in favourable outcomes in cases of resorption.⁷⁹ This can be **complicated by the loss of apical constrictions** if the resorptive cavity surrounds the terminus of the root (Figs 21 and 22). It is wise to favour a multiple visit approach as it is known that chemo-mechanical disinfection may not eradicate all pathogens. Corticosteroid/antibiotic pastes have been recommended as their placement has been seen to be associated with reduction of resorptive cells.⁸⁰ However, calcium hydroxide remains the gold standard⁸¹ as it eradicates bacteria, may necrotise cells in the resorptive lacunae, neutralise the acidic environment of the lacunae and also stimulate repair.^{49,82,83} Long term placement of calcium hydroxide has a significant negative effect upon fracture resistance of dentine.⁸⁴ As such dressings should not be left *in situ* for over 30 days.⁸⁴ Regular reviews are essential. Following this routine orthograde obturation should be performed. Surgical endodontics may be required when an orthograde approach is not possible. This would classically occur when there is impediment to the canals such as the presence of a post retained crown. An apparent lack of patency may also indicate a surgical approach (Figs 23a–d).

EIR associated with impacted teeth and/or expanding infra-bony lesions

Where impacted teeth are involved in a resorptive lesion several factors must be considered:

- Is the impacted tooth valuable for dental aesthetics and function?

also been advocated for improving both periodontal cell survival after avulsion and periodontal ligament repair.⁷⁴

Closed apex or open apex?

Revascularisation and maintenance of vitality is possible in teeth with incomplete apex formation if the tooth is replanted within 60 minutes of avulsion.^{75,76} If the apex is radiographically less than 1.1 mm in diameter this indicates incomplete formation.⁷⁶ Prevention of bacterial contamination is paramount in the drive for successful replantation therefore emersion in doxycycline has been shown to improve success.⁷⁷ Nonetheless approximately only

50% of such teeth may maintain vitality.⁶ If the apex is closed, patients should be advised about the merits of elective endodontics, which should ideally be performed in seven to ten days.⁷⁸ As the tooth is theoretically **vital** at replantation **single visit root canal treatment** may be performed if begun within seven to ten days. It may, however, be prudent to dress the tooth with calcium hydroxide and definitively obturate when healing is more advanced and the splint removed. This should be completed within one month (Figs 20a and b).⁶ For further information about the management of avulsed teeth the reader should refer to the International Association of Dental



Fig. 24 Early disto-apical resorption of the UR1 from an impacted 13. The 13 is not in a favourable position for exposure and alignment and the resorption of the 11 is minimal thus removal of the 13 is the optimal treatment plan

- If so, can the impacted tooth be exposed and aligned?
- Is the resorption so extensive that extraction of the affected tooth must be considered?
- Will removal of the impacted tooth have other associated morbidity?

Thus although removal of the associated stimulus (the impacted tooth) will halt the resorptive process,⁶ extra consideration must be given to further consequences of this, anticipating the importance of attempting to keep the impacted tooth and the long-term prognosis of the affected tooth (Fig. 24).

The management of resorption associated with expanding lesions is difficult and guided largely by the type of pathology involved. It is not within the remit of this article to discuss management of the non-infective infra bony pathologies themselves but the options invariably are related to excision of the lesion or local management. If a bony lesion is deemed so threatening that recurrence or significant expansion is likely, excision may be the only option. In this case the teeth will often be extracted as part of the excision. If non-excisional management is planned the lesion may be accessed, enucleated and/or curettage performed. As with the above example, some lesions may simply be drained. In these instances teeth



Figs 25a and b Metastatic carcinoma of the maxilla. The 21, 22 and 23 have all been rendered non-vital and resorptive activity initiated on the root surfaces. Extraction was contra-indicated as the risk of osteoradionecrosis was high and the patient had an additional risk of bisphosphonate induced osteonecrosis. The teeth were dressed with calcium hydroxide/iodoform (TG PEX -Technical & General Ltd)

may be left *in situ*. Orthograde root canal treatment will often be necessary as loss of vitality is common (Figs 25a and b).

EXTERNAL CERVICAL RESORPTION

Several factors have been associated with the stimulation of cervical resorption.⁵¹ Prevention is therefore important and this is especially apparent when internal bleaching is concerned.^{9,10} If there is a cervical defect that may expose external root surface to internally placed bleaching products these should be managed before treatment.⁸⁵ Once the access cavity has been prepared, the gutta percha and floor of cavity should be sealed to prevent passage of the bleaching agent through the dentine. It is recommended this is at least 2 mm thick. This can be done with glass ionomer, composites or materials such as Cavit or IRM.⁸⁶ The restorative material should be placed at the level of the cemento-enamel junction. This can be ascertained by using a BPE or **William's probe** to measure the distance from incisal edge to CEJ externally and ensuring that this length is not exceeded internally.⁸⁷ Carbamide peroxide 35% and sodium perborate with water have both been proposed as being suitable alternatives to hydrogen peroxide.⁸⁸ Other factors associated with cervical resorption include surgery/surgical trauma and periodontal therapy. In both these instances clinicians

should strive to avoid damage to the root cementum and periodontal ligament where possible.⁸⁹ As with apical resorption associated with orthodontics, a correlation with orthodontics and cervical resorption has been suggested.⁵¹ Thus excessive tipping force pressure should be minimised.

The focus of treatment is to access the resorptive lesion, remove resorptive tissue and restore the cavity.⁵⁰ The site, extent and pulpal involvement of the cervical resorptive lesion will dictate the treatment protocol. Heithersay suggests that Class 1-3 lesions are restorable but Class 4 lesions rarely so.⁸⁹ In addition, Class 3 and 4 lesions may present additional challenges: the presence of 'ectopic, bone-like' deposits within the cavity and multiple connections with the periodontal ligament that may impede complete curettage.⁴⁰ If the lesion is readily accessible and appears radiographically less advanced, direct non-surgical access may be possible.⁴⁰ If available CBCT will help establish the restorability without exploratory intervention³¹ but in many instances surgical exposure of the lesion is the only way of truly assessing the site and planning treatment. Alternative methods of treatment have been proposed. These include:

- Orthodontic extrusion, treatment of the lesion and orthodontic re-intrusion⁴⁰
- Access and management of the lesion from an internal approach alone⁹⁰

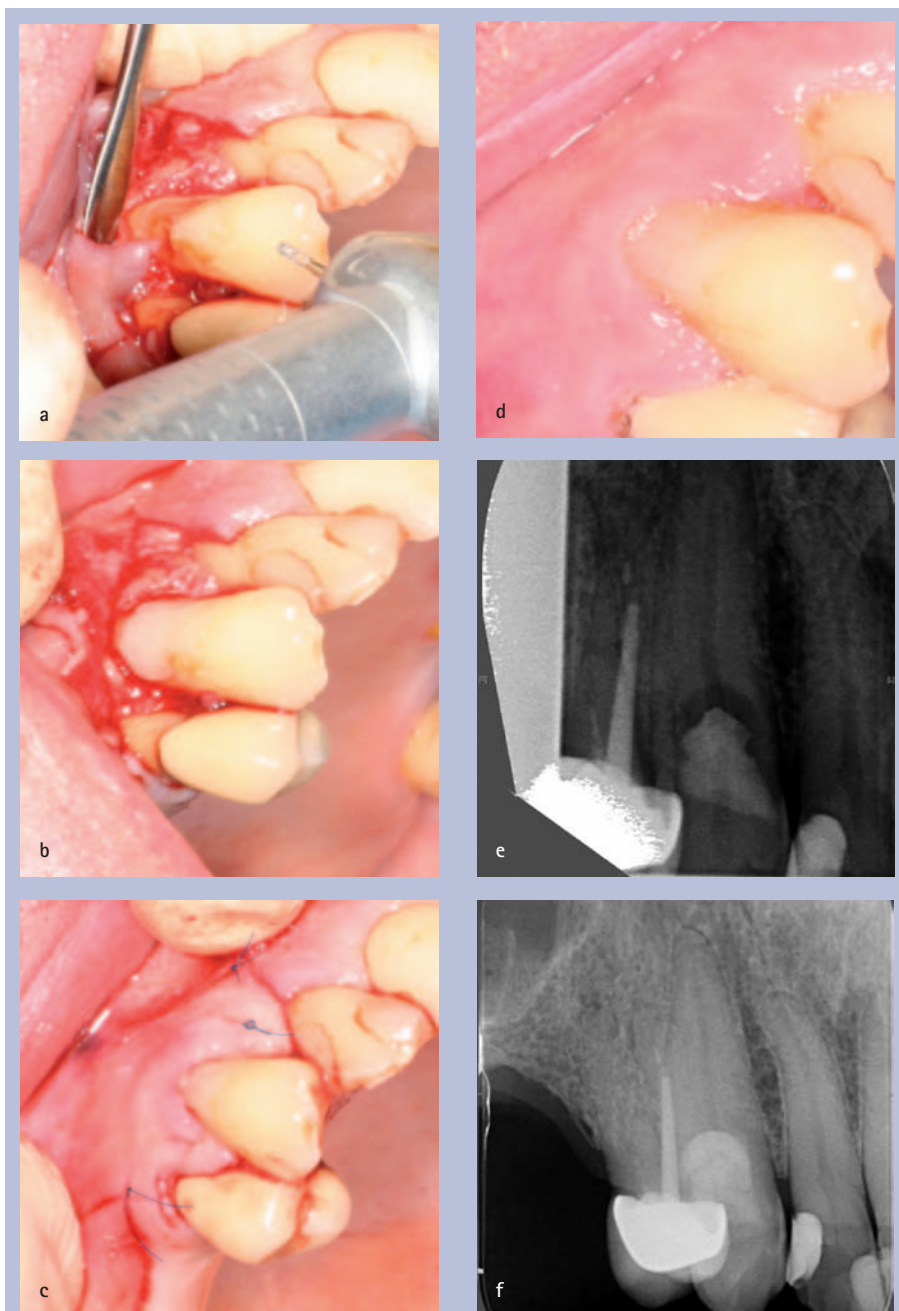


Fig. 26 ECR UR3: the GDP had attempted restoration but full access and curettage had not been performed. A full thickness muco-periosteal flap was raised to access the resorptive lesion, the area was curetted and the margins prepared. (a) Composite resin was placed (b) and the restoration re-contoured. The flap was replaced and sutured (c) with 5-0 Prolene (Ethicon, Inc, Johnson & Johnson). (d) shows the site at three month review. (e) and (f) show the radiographic appearance before and after restoration

- Extraction, management of the lesion and replantation⁹⁰
- Do nothing.⁴⁰

Ultimately, none of these alternative treatment methods are without limitation or risk of failure. As such, simple, direct surgical approach remains the mainstay of sensible treatment planning for lesions that cannot be accessed non-surgically.⁹¹

If there is pulpal involvement or suspected near pulpal involvement root canal

treatment should be performed. Heithersay recommends that root canal treatment should be instituted then the canal protected with a spreader before performing the surgical repair and finally completing the obturation.⁴⁰ It may, however, be more prudent to perform endodontic treatment electively beforehand. A full thickness flap should be raised to allow maximum visualisation and access to the site. Whether a surgical or non-surgical approach has been undertaken once the lesion has been

accessed management is largely the same: the site should be ideally isolated with rubber dam and sealant paste. The area should be thoroughly curetted until no bleeding is present and the cavity walls are sound. This will ensure that the vascular supply is not maintained and remaining resorptive cell front is removed and there is less likelihood of recurrence.⁴⁰ The cavity may be conditioned with 90% trichloroacetic acid. It is thought this process may improve the removal of resorptive cells to an extent not possible with mechanical debridement alone (and simultaneous removal of this tissue will minimise bleeding).^{51,92} Lavage with sodium hypochlorite and scrubbing with EDTA has also been advocated.⁹³ In Class 3/4 lesions, Heithersay⁹² recommends placing an intra-canal medicament, Ledermix paste (Blackwell), in the first visit (if RCT has not already been performed) and temporary dressing of Cavit (3M ESPE) in the resorptive cavity. Ten to 14 days later the site is reopened, if necessary further curettage performed, endodontic treatment completed and a permanent restoration placed in the resorptive cavity.

A range of materials may be used for restoration of the prepared cavity. Heithersay suggests the use of a glass ionomer.⁸⁹ The cavity can also be restored with composite (Figs 26a-f).⁶ The clinician should be guided by the conditions; composite will not be an option if isolation cannot be guaranteed. Mineral trioxide aggregate is an appropriate restorative material. It is biocompatible and has excellent sealing abilities plus the setting process requires moisture, which is ideal for such lesions.^{94,95} Indeed it is possible there could be regeneration of the periodontium as this has been shown to occur when the material is used as a retrograde obtundant in endodontics.⁹⁶ It is, however, difficult to handle and may 'wash out' in larger cavities. Although there is a paucity of data to support their use, newer materials such as Biodentine (Septodont) may prove to be the material of choice. Like MTA it consists of tricalcium silicate as well as calcium carbonate and zirconium oxide. As is the case for MTA, there is an uptake of silicone and calcium into adjacent dentine. **The former is thought to have a bioactive role, inducing local remineralisation. The latter forms calcium phosphate precipitates: apatite crystal formations at the**

boundary of material and dentine. These may result in improved physical strength and acid resistance.⁹⁷

In teeth exhibit external cervical resorption aesthetic considerations are paramount. Periodontal reattachment may not occur if the tooth has been restored with traditional restorative materials, so a periodontal defect may remain or the tissues may migrate apically resulting in compromised aesthetics.⁴⁰ Mineral trioxide aggregate may discolour and therefore may be contraindicated for restoration of anterior lesions. Clinicians may also consider the use of guided tissue regeneration after definitive repair to promote a differential tissue response and potentially heal regeneration of periodontal ligament (PDL).^{98,99} This may only be appropriate when the muco-periosteal flap can be placed at least 2 mm coronal to the defect margins.⁹⁹ The use of root surface conditioning agents and enamel matrix proteins to promote regeneration has been shown to be effective for certain periodontal defects.^{100–102} This technique is simpler than GTR as no membrane is required.⁹ Although of theoretical interest, there is a paucity of data to demonstrate the benefit of Emdogain after repair of resorptive lesions.

Management of multiple idiopathic cervical resorption lesions is challenging due to the progressive nature of the condition. The only definitive solution is extraction.¹⁰³ Surgical exposure, lesion curettage and restoration with various materials have been described.^{104,105} CBCT is useful in diagnosis. The site predisposes to attachment loss and periodontal disease therefore long-term supportive periodontal therapy is essential.¹⁰⁴ Finally, lesions tend to recur. Neely and Gordon¹⁰⁶ reported the follow-up of two patients, a father and son, over 22 years and despite eight procedures five extractions were required in the father. The son exhibited evidence of resorption in both maxillary first molars. Despite intervention the upper left first molar was extracted.¹⁰⁶ In these patients tooth loss is inevitable thus both patients and clinicians should accept any restorative intervention cannot prevent disease progression but may improve aesthetics and control pulp symptoms. All patients should be subject to regular clinical and radiographic reviews. Currently there are no guidelines about the frequency of reviews for two or

three dimensional imaging so sensible patient focused decisions should be made.

External replacement resorption

Once ERR is established there is no effective treatment. Progression will result in complete resorption of the root and eventual crown fracture. In older patients the progression is slow and may not require immediate treatment, indeed the tooth may last for years as a functional and aesthetic unit.¹⁰⁷ In younger patients, before or during the pubertal growth phase, the progression of ERR is more rapid and the need for further treatment must be anticipated.¹⁰⁷ The patient should be informed of this and routine monitoring should be instigated to allow more accurate prediction of when elective intervention may be necessary. Furthermore in the younger patient ankylosis may interfere with vertical development of the alveolar process.⁵² This may lead to improper function and compromised aesthetics. Thus, early intervention is essential. For management of ERR the following options maybe considered:

1. Accept position, restore the incisal level with composite and monitor

It is possible in the short to medium term to simply build an infra-occluded tooth up in composite to improve the aesthetics. This may be of further use in bone preservation before implant placement. In younger patients before or during the pubertal growth phase this option may not be suitable as the normal development of the alveolar process can arrest if the tooth is left *in situ*. In addition the tooth may be unacceptably long if restored and thus the aesthetics may remain significantly compromised.⁵²

2. Autotransplantation

Autotransplantation with a premolar has been proposed as a management technique.^{108,109} Apical development of the donor tooth must be considered and elective endodontic therapy of the tooth performed if the apex is fully developed as these teeth carry a higher risk of pulp necrosis.¹⁰⁹ Careful preoperative planning and atraumatic surgical technique are essential.¹¹⁰ Once transplanted the donor tooth can be disguised to give the appearance of the lost tooth. Contraindications to such an approach include: gross

discrepancies in donor tooth and recipient site size or proposed tooth shape, the possible need for future orthodontics, systemic health problems, patients older than 12–14 years and excessive damage to the alveolus of the recipient site.^{111,112}

3. Surgical repositioning

Extraction and replantation of the tooth has been advocated, theoretically breaking bony contact with the root and promoting healing.¹¹³ The tooth is extracted and replaced correcting vertical and/or horizontal discrepancies and functionally splinted or orthodontically anchored.^{114,115} A technique involving extraction of the tooth, reinforcement and augmentation with a titanium post and replantation met with limited success.¹¹⁶ There is a paucity of evidence to support such treatment plans.⁵²

4. Extraction

In adults a tooth with ERR may survive up to 20 years as the disease process is slow.¹⁰⁷ As such extraction would only be indicated if pathological fracture occurred or deemed likely or aesthetics were severely compromised. In children this should not be performed immediately after diagnosis but timed in conjunction growth phases.¹¹⁷ It has been suggested that extractions of teeth with ERR in children should be timed with the start of the adolescent growth spurt:¹¹⁸ 10.5–13 years old for girls and 12.5–15 years old for boys.¹¹⁹ Thus maintaining space and aesthetics up to the time of extraction while allowing vertical alveolar growth during puberty. Extraction of teeth with ERR is notoriously difficult, necessitating a surgical approach. As such there can be considerable bone loss and the defect may be worse.^{120,121} This may complicate both implant-based and convention restorative planning.^{122,123} If extraction is planned, socket/ridge preservation may be considered to minimise alveolar resorption.¹²⁴

After extraction the patient may have the space filled with a conventional fixed or removable prosthesis, an implant and prosthesis or have orthodontic space closure, expansion or maintenance in preparation for a restorative solution. Orthodontic space closure may not always be viable and the aesthetic outcome may be compromised with discrepancies in tooth size and symmetry. Furthermore, existing malocclusions,

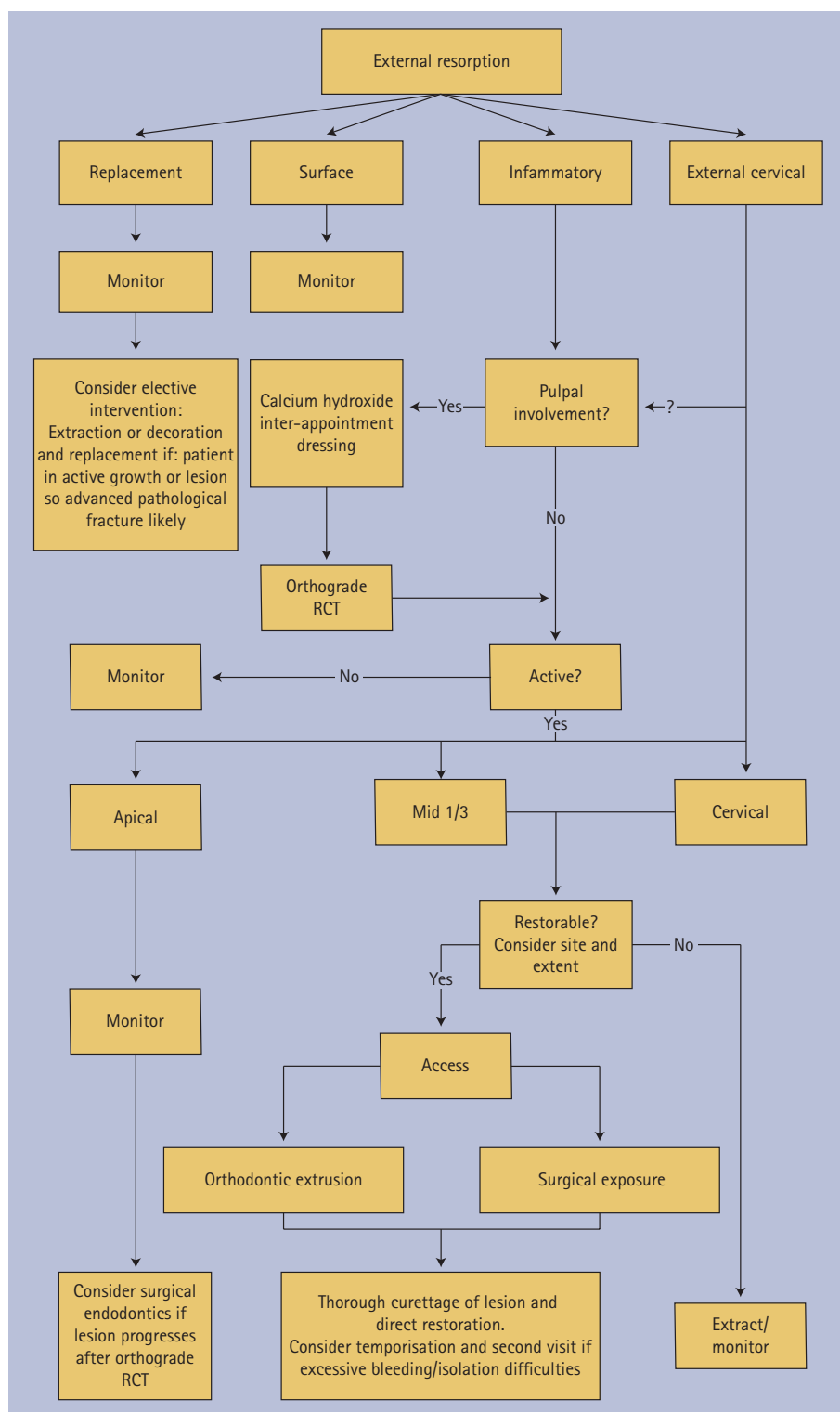


Fig. 27 A proposed algorithm for the management of external resorptive lesions

compromised dental health, cost of treatment and compliance problems may complicate or contra-indicate orthodontics.¹¹⁷

5. Decoronation

This may be regarded as a suitable alternative to extraction. It is indicated when the root is not expected to resorb within a year and/or the site is planned for routine restorative or implant retained prosthesis.¹¹⁷

It should not be considered if orthodontic space closure is planned. In the adult patient this may be considered two years before implant placement.¹¹⁷ In the growing child it may be indicated when the infraposition of the tooth advances to or beyond a quarter of the position it should be in.^{59,121} Decoronation prevents extensive bone loss associated with extraction and preserves alveolar ridge height and

width.¹²¹ Furthermore, it can be viewed as elective management when pathological fracture is likely or aesthetics are severely compromised.¹¹⁷ The suggested technique for decoronation is:

- Raise a full thickness mucoperiosteal flap
- Remove the crown using rotary instrument and smooth the root face to be flush with or just below the alveolar crest
- Removal of any root filling/ medicament that may induce inflammation or prevent bony growth
- Covering the root surface with a full thickness mucoperiosteal flap^{121,125}

Many of these techniques require specialist care. A recent Cochrane review indicates that there is very little evidence as to the optimal treatment option when management of the ankylosed tooth is concerned.¹²⁶ Extraction of these teeth is not without risk and the surgical deficit may be significant, potentially complicating future implant placement. Patients must consent to such associated morbidity. If pathological fracture is predicted, elective decoronation and provision of an overdenture or fixed prosthesis may be the optimum solution. Timing of intervention can be critical to minimise morbidity and optimise outcomes.

A recent proposal has been the management of terminal replacement resorption with the use of calcitonin. The rationale derives from the management of patients with osteoporosis. As the process of bony resorption is essentially similar to dental hard tissue resorption it is logical to assume that treatment rationales for catabolic bone disorders may also be advantageous for dental resorptive disorders. Drugs used include calcitonin, prostaglandin E2 and more notably for the dental profession, bisphosphonates. One study has demonstrated that bisphosphonates have no influence upon resorptive activity when used as an intra-canal medicament in replanted teeth.¹²⁷ Others have indicated a more positive outcome for modification of osteoclastic behaviour when lesions are treated with bisphosphonates.^{128,129} Limited conclusions can be extrapolated to the human model as these are *in vitro* or on animal models. The side effects of bisphosphonate therapy would likely render



Fig. 28 The placement of intra-canal medicament between visits. The 21 has been dressed with TG Pex. Extrusion into a lateral canal is evident

this treatment regimen unjustifiable to the majority of patients with resorptive lesions. A reasonable argument could perhaps be constructed for bisphosphonate therapy in patients with multiple-idiopathic resorptive lesions.

An algorithm for the management of external type resorptive lesions can be found in Figure 27.

Internal inflammatory resorption

The aim of treatment in internal resorption cases is to remove any stimulus and vital tissue that may be allowing the resorptive process to perpetuate. If the tooth is restorable, root canal treatment is usually the treatment modality of choice.¹³⁰ Endodontic therapy associated with internal resorption should be considered in two phases: chemomechanical debridement and obturation.

Chemomechanical preparation

Access should be minimal to preserve maximum tooth structure. In inflammatory resorptive cases the process can be complicated by excessive haemorrhage from the canal. If bleeding cannot be controlled, a perforation or a misdiagnosis and external cervical resorption may be considered.⁶ Furthermore if there is a replacement resorption the canal may be partially or completely obstructed. The



Figs 29a and b The System B (SybronEndo) and Obtura (Obtura Spartan Endodontics) for use in the continuous wave warm vertical condensation and warm flowable backfill

Table 1 Diagnostic features of resorption

Diagnosis	Mobility	Percussion	Colour	Vitality	Radiographic signs
External surface resorption	Normal	Normal	Normal	Normal	Minimal if at all: small cavity in the cementum and superficial dentine
External inflammatory resorption	Maybe increased	Normal	Normal, may change if pulpal involvement	Non-vital unless 'sterile' pressure resorption	Loss of lamina dura, irregular saucer shaped lesions with adjacent peri-radicular radiolucency
External cervical resorption	Maybe increased	Normal	Possible pink discolouration of cervical enamel	Normal, possibly increased response to vitality testing if lesion close to pulp. Absent if pulpal involvement.	Radiolucency of cervical third of root, may resemble class V cavities or internal resorption
External replacement resorption	Absent	Metallic sound	Normal, may change depending upon nature of trauma	Typically absent as sequelae of trauma	Irregular alteration to root form, loss of lamina dura, bony infiltration resorptive cavities with direct apposition of bone onto root surface. Absence of radiolucency of the periodontal ligament.
Internal inflammatory resorption	Normal	Normal	Possible pink discolouration if lesion is coronally situated	Mixed response: positive in active lesions, absent in extensive lesions	Expansion of canal, often symmetrical with sharp, well-defined margins
Internal replacement resorption	Normal	Normal	Possible pink discolouration if lesion is coronally situated	Mixed response: positive in active lesions, absent in extensive lesions	Irregular expansion of canal. Possible pulpal obliteration with mixed radio-opacities in the canal space

former can be managed by mechanical extirpation of the pulp tissue with copious lavage. If there are anatomical discrepancies or blockages, the canal form is often impossible to clean mechanically although long shank burs and diamond tipped endosonics may help. Chemical

disinfection of the canal system therefore must be considered essential, hypochlorite being the irrigant of choice.¹³¹ Passive ultrasonic irrigation may be used as an adjunct.¹³² The combination of cavitation and acoustic streaming produced by the use of ultrasonics can further aid both

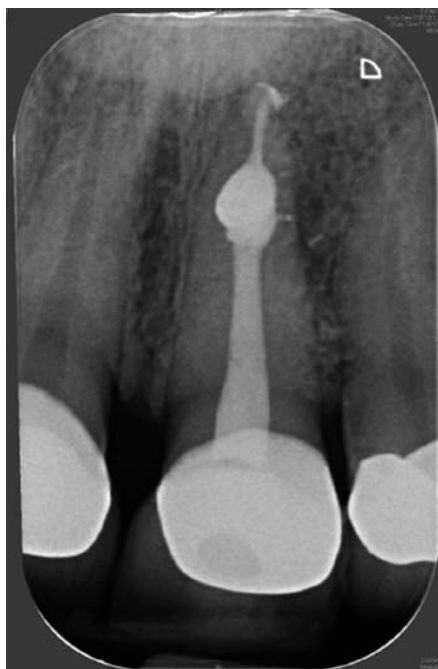


Fig. 30 The 21 has been obturated with a combination of continuous wave warm vertical compaction and warm flowable gutta percha backfill

chemical and mechanical cleansing.¹³³

Even with this combination it may be impossible to totally eliminate bacteria from the irregular crypts of the resorptive area.^{134,135} Intra canal medicaments must be used to further decontaminate the intricacies of the canal system thus single stage root canal treatment is not advocated. The current modus operandi is for the placement of an inter appointment calcium hydroxide paste.¹³⁶ The combination of sodium hypochlorite and calcium hydroxide has been shown to significantly reduce the number of bacteria (Fig. 28).¹³⁷

Obturation

Consideration must be given to obturation of both the canal apical to the resorptive cavity and the resorptive cavity and coronal canal. The apical portion may be obturated with cold lateral condensation, warm vertical compaction or continuous wave compaction. Flowable gutta percha and vertical condensation is then necessary for optimum three-dimensional obturation of the resorptive cavity (Figs 29a-b and 30).^{133,138,139} Carrier-based systems may not obturate the resorptive cavity. If the lesion has perforated the canal wall it has been shown that mineral trioxide aggregate (MTA) is the material of choice for repair.¹⁴⁰ Case reports suggest the canal should be obturated with gutta-percha to the level of

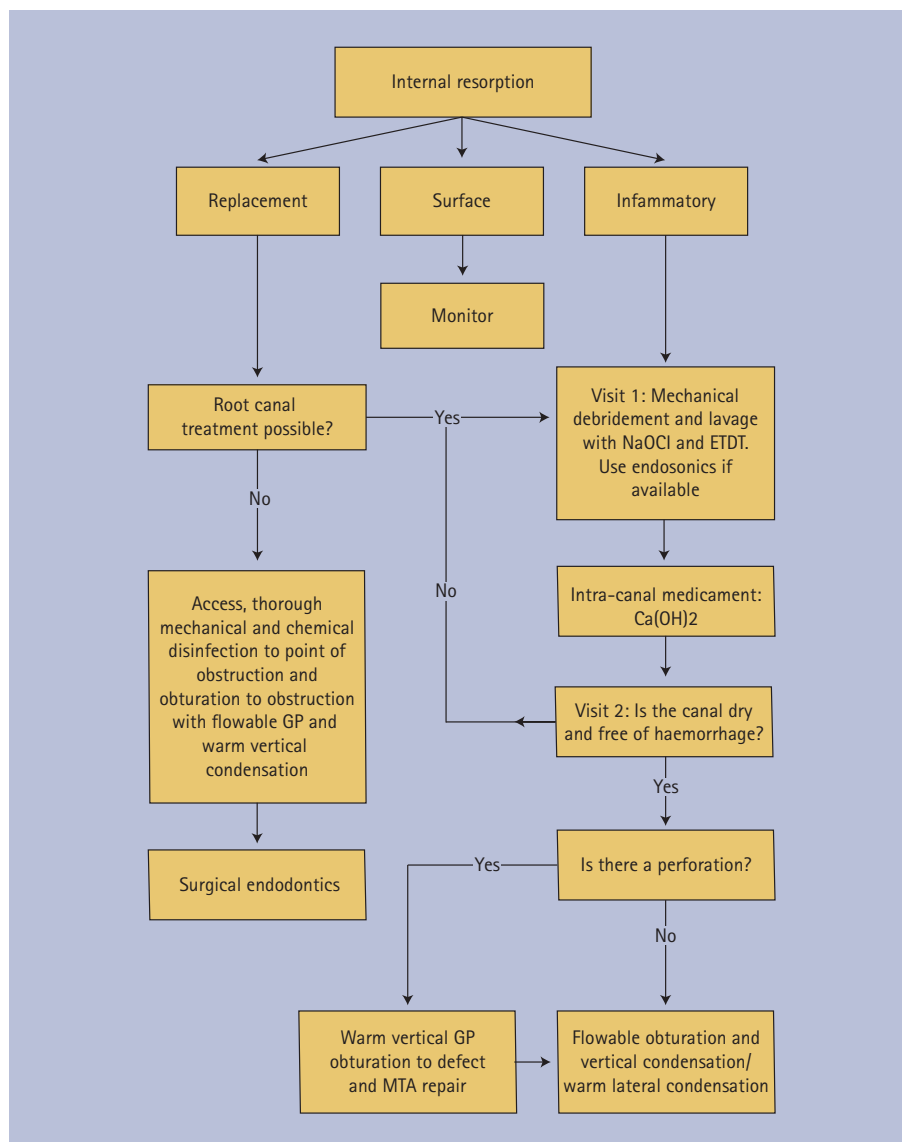


Fig. 31 A proposed algorithm for the management of internal resorptive lesions

the lesion and an MTA dressing placed to fill the cavity.^{141,142} A muco-periosteal flap may have to be raised to ensure isolation and complete obturation of the perforation. Where there is no perforation and the remaining tooth is not significantly undermined the prognosis is good for treatment of internal resorption.¹⁴³ See Figure 31 for an algorithm to aid in the management of internal resorption.

Internal replacement resorption

Management protocols should follow that for internal inflammatory resorption but the clinician must be aware of an additional level of complexity owing to calcific tissue within the canal. The lesion should be thoroughly curetted. The application of 90% trichloroacetic acid may help inactivate the lesion.^{40,92} The use of endosonics may aid removal of mixed calcific tissue

obstructing access. Orthograde root canal treatment may not be possible and surgical endodontics may be considered to be the only option.

An algorithm for the management of internal type resorptive lesions can be found in Figure 31.

CONCLUSIONS

Resorption presents with a range of aetiologies and prognoses. A thorough understanding of the pathology is essential to allow appropriate treatment planning. Management can be challenging. **Timely intervention is essential for optimum management.** Practitioners must be aware of when to intervene and have the confidence to do so. Delays in treatment via late diagnoses and referral waiting times may be catastrophic. The outcome for treatment may be uncertain and patients

should always be well informed of this. This review presents algorithms for treatment planning which should assist management of resorptive lesions in a timely and appropriate fashion thus improving the long term prognosis for teeth presenting with resorptive defects.

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