Tooth Resorption

Resorption can be a physiologic or a pathologic process, and results in loss of dentin, cementum, or bone. Resorption may occur subsequent to traumatic dental injuries, orthodontic treatment, or chronic infections of the pulp or periodontal tissues.

Under normal circumstances, the mineralized tissues of permanent teeth are resistant to resorption. They are protected by a layer of predentin and precementum, on which clastic cells cannot gain foothold. If, however, this protective layer is damaged or altered by an injury in conjunction with an inflammation of the pulp or periodontal tissues, then multinucleated clastic cells will induce resorption.

Tooth resorption is classified on the basis of the site, nature, and pattern of the process (Ne et al., 1999). A distinction is generally made between internal and external resorption. External resorption can be further subdivided into external surface resorption, invasive cervical resorption, inflammatory root resorption, ankylosis, and replacement resorption.

**Internal resorption** is the only type of resorption that starts within the root canal, and it frequently results from chronic inflammation of the pulp. Vital pulp tissue is a prerequisite for active internal resorption. In the initial stage, the coronal portion of the pulp is totally or partially necrotic, whereas the apical pulp, which includes the internal resorption defect, can remain vital and inflamed. Therefore, pulp sensibility tests can remain positive (Trope, 2002).

Internal resorption is generally asymptomatic and is usually identified by chance on routine radiographs.

**External surface resorption** is a transient phenomenon in which the root surface undergoes spontaneous destruction and repair. It is found in all teeth, in varying degrees, and is probably a normal physiologic response. Hence, it requires no treatment (Ne et al., 1999).

**Invasive cervical resorption** is an insidious and often aggressively destructive form of external tooth resorption. It is a relatively uncommon condition that may occur in any tooth of the permanent dentition. It is characterized by invasion of the cervical region of the root by fibrovascular tissue, derived from the periodontal ligament. This resorptive process leads to progressive loss of tooth structure and may eventually invade the pulp space. However, the pulp survives until late in the resorative process, because it is protected by the predentin and odontoblasts (Heithersay, 1999a). The etiology of this condition is poorly understood, but intracoronal bleaching, trauma, orthodontics, dentoalveolar surgery, and periodontal treatment have been cited as potential predisposing factors (Heithersay, 1999b).

In **inflammatory root resorption**, the necrotic, infected pulp provides the stimulus for periodontal inflammation. The most common cause of external inflammatory root resorption is trauma. If the cementum has been damaged, leaving the dentinal tubules exposed, this creates an open communication between the internal and external surfaces of the root. Bacteria and their by-products, and tissue breakdown products from within the pulp space, diffuse through the dentinal tubules and stimulate an inflammatory response over large areas of the periodontal ligament, leading to aggressive and progressive resorption of the root (Andreasen, 1981).

**Ankylosis** and **replacement resorption** are primarily associated with a history of luxation injuries, in particular in avulsed teeth with an extended extra-oral dry time. If osteoblasts are able to cover the root surface after necrosis of the periodontal ligament, direct contact with bone and root will occur over some areas of the root surface. The term for this condition is ankylosis. Reversal of ankylosis is possible if less than 20% of the root surface is involved. If not, the root will gradually be replaced by bone (Tronstad, 1988).
Diagnosis of Resorption

It can be difficult to distinguish between invasive cervical resorption and internal root resorption. This may result in an inaccurate diagnosis and subsequently incorrect treatment.

Radiographically, internal resorption appears as a circumscribed, oval-shaped enlargement of the root canal space. The outline of the root canal is often distorted, and the resorption appears to be contiguous with the root canal. Regardless of the projection angle of the radiograph, internal resorption remains centered in the root.

Invasive cervical resorption moves away from the canal if the angle of projection of the radiograph is changed. In addition, the root canal outline appears normal and can usually be identified through the defect, in contrast to internal resorption.

Clinically, the presence of a pink spot in the coronal dentin can be a feature of both internal and invasive cervical resorption. This phenomenon occurs due to the presence of granulation tissue just under the enamel. In both conditions, a pulpal sensibility test is likely to be positive, because the pulp remains (partially) vital.

42.1 Internal root resorption

Left: Perpendicular periapical radiograph showing an internal resorption defect on tooth 42 with an apical radiolucency. Note the oval, circumscribed radiolucent enlargement of the root canal.

Middle: A radiograph taken from a different horizontal angle shows that the defect stays centered in the root.

Right: Postoperative radiograph confirms that the entire canal including the internal resorption defect has been filled, in this case with MTA. Failure to achieve this would indicate the presence of external resorption defect.

42.2 Invasive cervical resorption

Left: Radiograph showing invasive cervical resorption on tooth 13. The outline of the canal is clearly visible through the resorption defect. The tooth tested vital.

Middle: A pink spot on the palatal surface indicates the presence of granulation tissue undermining the enamel.

Right: The 1.5-year follow-up radiograph showing the resorption defect restored with a composite filling. Pulpal sensibility tests were positive, and there were no signs of periapical pathosis.

42.3 Severe internal resorption on two maxillary central incisors

Left: Teeth 11 and 21 exhibiting reddish and black discoloration, due to internal resorption, respectively.

Middle: Extensive radiolucencies in the coronal and cervical segments of the root canals of 11 and 21.

Right: Palatal aspect of affected central incisors. The teeth have been significantly weakened as a result of the resorption. Soon after the initial examination, the crown of tooth 11 broke off.
External inflammatory root resorption is always accompanied by resorption of bone, so radiolucencies in the root and the adjacent bone can be identified on the radiograph. Because external inflammatory root resorption is associated with an infected pulp, there will be a negative response to a pulp sensibility test.

Pressure has also been identified as a possible etiological factor for external inflammatory root resorption, as evidenced by resorption that may occur in conjunction with orthodontic tooth movement, tooth eruption, tumors, cysts, and impacted teeth. In such cases, the resorption tends to cease as soon as the source of pressure is removed (Ne et al., 1999).

Clinically, ankylosis and replacement resorption are recognized by immobility of the affected teeth. Depending on the age at which the ankylosis has occurred, the tooth may be in infraocclusion. The percussion test is an important diagnostic tool, because a typical metallic percussion sound is produced when these teeth are tapped, which is very different from sound produced on tapping the healthy adjacent teeth. Radiographic features include absence of a periodontal ligament space. Replacement resorption may give the tooth a “moth-eaten” radiographic appearance, with irregular borders.

42.4 External inflammatory root resorption
Left: Severe external inflammatory root resorption in 11 and 21 after avulsion of 11 and intrusion of 21. Timely root canal treatment could have prevented this.
Middle: External inflammatory root resorption in conjunction with orthodontic treatment, which ceased following its conclusion.
Right: External inflammatory root resorption in tooth 17, probably due to longstanding pressure from a third molar, which had been extracted a few years earlier.

42.5 External inflammatory root resorption after dental trauma
Left: Sixteen-year-old girl who sustained trauma with a hockey stick 3 months previously. Teeth 41 and 42 were avulsed and reimplanted within 10 minutes. Unfortunately, root canal treatment was postponed, which resulted in external inflammatory root resorption in both teeth. Two sinus tracts can be identified.
Right: Radiograph showing tracing of the fistulous tracts with gutta-percha cones. Multiple radiolucencies in the roots and bone are visible.

42.6 Replacement resorption
Left: A 7-year-old patient sustained trauma with avulsion of tooth 11. It was replanted after 1 hour extra-oral dry time.
Middle: Several months later, signs of replacement resorption can be identified. An apexification procedure using calcium hydroxide was initiated; the tooth was filled with an apical plug of MTA and a build-up of composite resin.
Right: Six-month follow-up radiograph showing infraposition of tooth 11, due to replacement resorption.
The recommended treatment for internal resorption is conventional endodontic therapy to stop the process at an early stage and prevent the onset of a perforation. If a perforation has already occurred, the treatment is not very different from that of repairing an iatrogenic perforation. In addition to closing the perforation, measures must be taken to strengthen the tooth and to prevent it from fracturing. Adhesive restorations with composite are recommended to increase resistance to fracture.

Inflammatory root resorption resulting from pulpal necrosis or periodontal injury should be treated by root canal treatment. By disinfecting the pulp canal space, the inflammatory stimulus will be restrained, and the external inflammatory resorption can be arrested. In most cases, favorable healing with laying down of cementum will occur, but if a large area of the root is affected, osseous replacement may take place. Trope (1995) has recommended the use of a long-term dressing of densely packed calcium hydroxide in cases in which inflammatory root resorption has been established. Calcium hydroxide can create an alkaline pH in the surrounding dentinal tubules, and can kill bacteria and neutralize endotoxin, a potent inflammatory stimulator.

### 42.7 Treatment of internal resorption

Left: Patient referred endodontic treatment of tooth 45.

Middle: Obturation of such internal defects is best performed with a warm filling technique. The Obtura II gun (Obtura/Sportan, MI, USA) was shown to provide the best results, and lateral compaction the worst, when comparing various methods of obturating experimental resorptive defects (Goldberg et al., 2000).

Right: Obtura II gun, a delivery system for thermoplasticized gutta-percha or Resilon (Pentron Clinical Technologies, Wallingford, CT, USA).

### 42.8 Treatment of inflammatory root resorption

Left: This is the same patient as shown in Figure 42.5. Teeth 41 and 42 were avulsed and reimplanted within 10 minutes. The teeth were rigidly splinted for 6 weeks in contravention of the guidelines, which recommend 1–2 weeks using a flexible splint.

Middle: Timely root canal treatment could have prevented the external inflammatory root resorption of teeth 41 and 42.

Right: Three months after the trauma, root canal treatment was initiated.

### 42.9 Perforation repair and follow-up

Left: As a result of the inflammatory resorption, tooth 41 appeared to have two perforations. After an intracanal dressing of calcium hydroxide, MTA was used for perforation repair, and the remaining segments of the canals were filled with gutta-percha and sealer.

Middle: 3.5-year follow-up radiograph showing resolution of the apical and lateral radiolucencies of teeth 42 and 41.

Right: Clinical view after 3.5 years, revealing a healthy periodontium.
Treatment of Invasive Cervical Resorption

The aim of the treatment of invasive cervical resorption is removal or inactivation of all active resorptive tissue and the restoration of the defect with a good sealing fill material. This procedure can be very challenging, due to the infiltrative nature of the resorption in later stages. More advanced resorption lesions are characterized by a series of small channels, often interconnecting with the periodontal ligament apical to the primary lesion.

Depending on the extent of the resorptive process, such cases are divided into four classes in order of severity (Heithersay, 1999b). With more advanced lesions, in which complete removal would cause severe damage to the tooth, an attempt can be made to cut off the blood supply to the resorptive tissue. Heithersay (1999c) has shown good results using topical application of a 90% aqueous solution of trichloroacetic acid (TCA) in the treatment of class I and II cases. This agent causes coagulation necrosis of the resorptive tissue, without negatively affecting the potential for repair of the adjacent tissues. It has the potential to inactivate tissues in the channels that would normally remain inaccessible to mechanical debridement.

42.10 Classification according to Heithersay
Class I: A small resorptive lesion near the cervical area with shallow penetration into dentin.
Class II: A well-defined resorptive lesion that has penetrated close to the coronal pulp chamber, but exhibits little or no extension into the radicular dentin.
Class III: A deeper invasion of dentin by resorbing tissue, extending into the coronal third of the root.
Class IV: A large invasive resorptive process that has extended beyond the coronal third of the root.

42.11 Treatment of invasive cervical resorption class II
Left: Patient was referred for retreatment of tooth 46. The radiograph reveals a cervical resorptive defect on the distal aspect of the tooth.
Middle: Retreatment has been completed; there was no communication between the root canal system and the resorptive defect.
Right: A flap was elevated to gain access to the resorptive lesion, and a topical application of TCA was used to inactivate the granulomatous tissue.

42.12 Restoration of the defect with composite and follow-up
Left and middle: After inactivating the granulomatous tissue, another challenge is presented—restoration of the defect. In this case, a composite restoration was placed, but due to its location below the attachment level, may promote build-up of a periodontal pocket. At best, a long epithelial attachment may ensue.
Right: Three months after surgery, buccal gingival recession of 2 mm is evident. Probing depth is 3 mm but there is no bleeding on probing.
The resorptive tissue can be accessed either by an external approach, an internal approach, or by a combination of the two. When using an external approach, a periodontal pocket often persists after restoring the defect. This problem may be overcome by orthodontic extrusion of the tooth before treatment, which will improve access to the defect and provide a supragingival margin for the restoration.

If the resorption is extensive, elective endodontic treatment may be required to allow visualization of the area and to gain access to the more deeply infiltrating tissue surrounding the root canal.

42.13 Treatment of a class III resorptive lesion using an internal approach

Left: Invasive cervical resorption on tooth 35. Pulpal sensibility testing was positive and there were no significant probing depths.

Middle: Eccentric projection radiograph shows an undistorted outline of the root canal, which is visible through the defect. Elective endodontic treatment was recommended to enable access to the resorptive process.

Right: On opening the tooth, a white line surrounding the root canal is visible, representing a layer of predentin.

42.14 Topical application of TCA

Left: After cleaning and shaping the root canal and applying TCA to inactivate the granulomatous tissue, an intracanal dressing of calcium hydroxide, which also has tissue-dissolving properties, was applied.

Middle and right: The root canal has been filled (second visit). The coronal third of the root has been affected by the resorptive process. The goal of TCA use is to cut off the blood supply to the resorptive tissue in the channels.

42.15 Definitive composite restoration and follow-up

Left: A composite build-up has been made, to obtain a coronal seal and to reinforce the tooth that has been weakened by the loss of dentin resulting from the resorption.

Middle and right: At the 1-year follow-up, the radiograph shows no signs of pathosis or recurrence of the resorption. Probing depths are within normal limits, and the patient is free of symptoms.

The treatment of class IV lesions has a high failure rate (Heithersay, 1999c), raising the question as to whether an attempt should be made to treat such cases. Extraction and replacement with an implant or bridge has been recommended (Trope, 2002). An alternative would be to leave the resorption untreated and inform the patient that tooth loss may occur in the future.

The speed of spread of invasive cervical resorption has not been investigated, but clinical observation suggests that, in the absence of infection, progress is slow.
Currently, there is no reliable procedure that can cause arrest of replacement resorption after its initiation. The resorbing cells in ankylosis and replacement resorption are osteoclasts. Osteoclasts are normally involved in bone remodeling and are unable to distinguish between cementum, dentin, and bone. Therefore, replacement resorption and ankylosis should be considered as physiologic, rather than pathologic processes (Tronstad, 1988). Since replacement resorption is primarily associated with luxation injuries, it is of paramount importance to prevent these injuries from occurring. The use of a mouth-guard in contact sports has proven to be effective. Furthermore, after an injury has taken place, additional damage should be minimized. In the case of an avulsion, extra-oral dry time should be minimized by immediate reimplanting of the tooth or storing it in an appropriate medium (e.g., milk).

Another strategy is to make the cementum more resistant to resorption after an extended extra-oral dry time. Emdogain (Staumann, Basel, Switzerland) has been recommended for promoting development of new periodontal ligament from the socket. However, treatment results have varied (Filippi et al., 2002; Schjott et al., 2005), and therefore its use is still controversial. Emdogain is not yet available worldwide.

**Avulsion of teeth 11 and 21**

This patient was involved in a bicycle accident, during which she sustained severe dental trauma. Teeth 11 and 21 were avulsed and fractured, tooth 22 was luxated, and the alveolar process was fractured. Teeth 11 and 21 were reimplanted by an oral surgeon after 30 and 45 minutes extra-oral dry time, respectively, and a rigid splint was placed. At the first visit, 1 week after the accident, the splint was adjusted for patient comfort and to enable the patient to carry out proper oral hygiene.

**Root canal treatment and removal of the splint**

Left: One week after the accident, endodontic treatment was carried out on teeth 11 and 21. Right: The splint was removed after 4 weeks. Before the accident occurred, the maxillary dental arch was uniform and regular. After the reimplantation, teeth 11, 21, and 22 appeared to be malpositioned. The patient declined orthodontic treatment, and chose to have the malpositions masked with composite veneers.

**Follow-up**

Left: Clinical picture after completion of the restorative treatment. Teeth 12, 11, 21, and 22 were provided with composite veneers. Right: Seven-year follow-up radiograph showing replacement resorption on teeth 11 and 21. Note the absence of the periodontal ligament space on the distal aspect of 11 and 21. Clinically, a high metallic percussion sound confirmed the diagnosis. The speed at which replacement resorption takes place varies, and may take years to decades. Tooth 21 also reveals a severe invasive cervical resorption.
Additional Topics

43 Perforations

A root perforation is a mechanical or pathologic communication formed between the supporting periodontal apparatus of the tooth and the root canal system (AAE glossary, 2003). Perforations occur as a complication of endodontic treatment and restorative procedures such as post preparation; the reported rate ranges from 1% to 3% (Kerekes and Trondstad, 1979; Eleftheriadis and Lambrianidis, 2005; Jamani and Fayyad, 2005). In addition to iatrogenic perforations, pathologic processes such as tooth resorption or caries may also result in root perforation.

Kvinnsland et al. (1989) evaluated the etiology and location of 55 root perforations seen in a dental school in Norway. Almost 50% of the perforations were due to endodontic treatment and slightly more than 50% were due to prosthodontic treatment. The buccal and mesial root surfaces, as well as the midroot areas, were most often perforated.

According to Fuss and Trope (1996), the important factors in determining the success of a perforation repair are the time interval between the occurrence of a perforation and its repair, the size of the perforation, and its location. The authors presented a classification of root perforations based on the above factors.

The location of the perforation in relation to the level of the epithelial attachment and crestal bone is probably the most important factor in terms of prognosis. The closer the perforation is to this critical zone, the poorer the prognosis, due to susceptibility of the site of perforation to contamination from microorganisms from the oral cavity. Moreover, if the perforation is not closed immediately, apical migration of the epithelial attachment may occur, resulting in a periodontal defect. Fuss and Trope (1996) concluded that successful treatment depends mainly on immediate sealing of the perforation and prevention of infection.

### Classification of Root Perforations

<table>
<thead>
<tr>
<th>Good prognosis</th>
<th>Poor prognosis</th>
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<tr>
<td>– Fresh</td>
<td>– Old</td>
</tr>
<tr>
<td>– Small</td>
<td>– Large</td>
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<tr>
<td>– Apical-coronal</td>
<td>– High alveolar ridge</td>
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43.1 Perforations caused by a procedural error, caries, or a resorption process

Left: Radiograph showing a crestal perforation, due to a misaligned post placement.

Middle: Radiograph showing deep caries resulting in perforation.

Right: Radiograph showing cervical invasive resorption resulting in perforation.
Diagnosis of Perforation

As the time interval between the occurrence of the perforation and its repair is an important prognostic factor for treatment outcome, early determination of the occurrence of a perforation is of paramount importance. A diagnosis is established based on clinical and radiographic findings. Radiographs from different angles, including bitewing radiographs, are indispensable for an accurate diagnosis. In addition, the presence of a sinus tract or the appearance of localized problems such as pocket formation or furcation involvement may indicate the existence of perforation (Aldahainy, 1994).

During treatment perforations can be identified by direct observation through the microscope, direct observation of bleeding at an unanticipated location, indirect bleeding assessment using a paper point, and the use of an apex locator. Moreover, reports of sudden and unprovoked pain may indicate that the file is penetrating the surrounding bone.

Management of perforations will depend on a number of factors, including the size and location of the perforation and access to the perforation site. Subgingival perforations can usually be repaired with materials such as amalgam, composite or cast metal restorations, by extending the cervical margin to include the defect.

43.2 Subgingival perforation

Left: Radiograph showing a maxillary first molar with a large restoration and an insufficient root canal filling in the mesial root. Because a crown has been planned on tooth 26, retreatment is appropriate. Localized gingivitis is present between teeth 25 and 26, and a perforation is suspected on the mesial aspect of tooth 26, because of the close proximity of the restoration to the interdental papilla.

Right: After removing the composite restoration, a subgingival perforation became visible.

43.3 Perforation sealed with composite

Left: Prior to initiating the root canal treatment, the perforation has been sealed with a composite restoration. A second mesiobuccal canal has been detected and instrumented.

Middle: Four canals have been obturated.

Right: A fiber post has been placed in the palatal canal, and a build-up of composite core material has been constructed.

43.4 Follow-up

Left: Postoperative radiograph.

Right: At 6-month follow-up, a crown has been placed that encompasses the defect; the gingiva is free of inflammation and the patient is symptom-free.
Management of Perforations

The primary goal in management of perforations is to arrest the inflammatory process and the subsequent loss of tissue attachment by preserving healthy tissues at the site of the perforation. Many materials have been used to repair perforations, including: amalgam, Cavit (3M-ESPE, St. Paul, MN, USA), calcium hydroxide, super-EBA, glass ionomer, composite, gutta-percha, and zinc oxide eugenol cement. The success rate of these materials has been variable.

Since the introduction of MTA, substantial evidence has collected that it is the material of choice for perforation repair (Lee et al., 1993; Pitt Ford et al., 1995). It is biocompatible, provides a tight seal, and promotes the regeneration of cementum, thus facilitating the regeneration of the periodontal tissues. This characteristic differentiates MTA from other comparable materials.

Main et al. (2004) presented a series of cases that demonstrated consistent healing with the use of MTA as a perforation repair material. The main advantage of MTA is its long setting time; however, this makes the material unsuitable for the repair of supracrestal perforations. If MTA comes into contact with oral fluids, it will wash out before setting.

43.5 MTA
MTA is available in the original gray-colored preparation (left), and the newer white-colored version (right). The latter is indicated for esthetically demanding areas of the mouth. The main difference between the two varieties is that white MTA does not contain iron. Moreover, the handling characteristics have been improved in the white preparation. Numerous publications have reported that MTA and Portland cement are identical materials, except that bismuth oxide has been added to MTA to give the material its radiopacity (courtesy of Dentsply Maillefer).

43.6 Perforation after post placement in the apical segment of a root canal
Left: The patient presented with severe swelling and pain in the area of tooth 47. Radiograph showing a large radiolucency. The bridge had been seated several years earlier.
Right: An access opening was made through the existing abutment, and the post was removed with the use of ultrasonics. The root filling material from the mesial canals was also removed.

43.7 Repair of the perforation with MTA and follow-up
Left: The distal canal has been filled with an apical plug of MTA and the mesial canals with gutta-percha and sealer. At the second visit, the setting of MTA was confirmed and the access opening was restored with composite.
Right: 2.5-year follow-up radiograph showing progressive osseous healing.
Additional Complications

A serious complication that may occur after creation of a root perforation is penetration of sodium hypochlorite through the perforation into the surrounding tissues (Neaverth and Swindle, 1990). The consequences of such an incident include an immediate burning sensation, severe pain, and marked facial swelling. In addition, it may lead to the subsequent development of a fistula, postoperative skin complications, ulcerations, and neurologic complications such as anesthesia, paresthesia (Reeh and Messer, 1989), and facial nerve weakness (Witton et al., 2005).

Whenever sodium hypochlorite has penetrated into the surrounding tissues, the dentist should inform the patient about the cause and nature of the incident. In many cases no, or only a minimal amount of, intervention is necessary. To relieve the acute pain, analgesics may be prescribed, together with cold compresses to reduce the swelling.

Antibiotics are recommended only in cases where there is a high risk of spread of infection. After the acute symptoms have resolved or diminished, endodontic treatment may be completed.
If the perforation is associated with a large osseous defect, it may be beneficial to use an extra-radicular matrix to prevent extrusion of the repair material. Most publications agree that using a matrix allows better control of the repair material (Lemon, 1992; Aldahainy and Himel, 1994). Whether this will result in a better treatment outcome remains to be demonstrated.

Matrix materials should be biocompatible and bioresorbable. A number of materials have been used as matrix materials, including tricalcium phosphate, hydroxyapatite, demineralized freeze-dried bone, collagen, and calcium sulfate.

After controlling the hemorrhage, the repair material is placed using appropriate instruments. In the case of MTA, carriers or small spatulas are used to deliver the material to the perforation site. It has been shown that indirect ultrasonic activation of MTA results in a denser filling than with hand compaction (Yeung et al., 2006). This can be achieved by using a plugger to compact the MTA and having the dental assistant touch the plugger with an ultrasonic tip at the same time.

If MTA becomes too moist during compaction, thick paper points may be used to wick out the surplus moisture.

**Application of Mineral Trioxide Aggregate (MTA)**

If the perforation is associated with a large osseous defect, it may be beneficial to use an extra-radicular matrix to prevent extrusion of the repair material. Most publications agree that using a matrix allows better control of the repair material (Lemon, 1992; Aldahainy and Himel, 1994). Whether this will result in a better treatment outcome remains to be demonstrated.

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**Armamentarium**

The consistency of the mixture of MTA is critical for correct handling. It should have the consistency of wet sand, and the pellet that is extruded from the carrier should retain its form.

Right: Dovgan MTA carriers are available in three different diameters (ADS, Vaterstetten, Germany).

**Perforation in the furcal floor of a maxillary molar, with attachment loss**

Left: The patient was referred for retreatment of tooth 16. The radiograph reveals a periradicular lesion. A sinus tract was present, which was traced with a gutta-percha cone.

Middle and right: The presence of a sinus tract and pocket formation may indicate the existence of a perforation. In this case, a probing depth of 8 mm on the buccal aspect was observed.

**Localizing the perforation**

Left: After removal of the restoration, a perforation was made apparent by profuse bleeding from the floor of the pulp chamber.

Middle: The bleeding tissue was partly removed using an electrosurgical tip. After removing gutta-percha from the canals, a second mesiobuccal canal was identified.

Right: After establishing working length with an apex locator and two radiographs, all canals were cleaned and shaped, and a dressing of calcium hydroxide was placed in the canals and the perforation site. A second visit was then scheduled.
Because MTA needs at least 3 hours to set, a moist cotton pellet is placed over the material and the tooth is sealed with a temporary restoration. On re-entry, MTA should be completely set and well fitted to the perforation site. Subsequently, the tooth should be definitively restored as soon as possible with an adhesive material to prevent coronal leakage.

Perforations in the furcation area of multirooted teeth are usually considered as crestal perforations, because of the close proximity to the epithelial attachment and possible communication with the gingival sulcus. According to Fuss and Trope (1996), the rate of success of their repair is low, because these furcal perforations are most susceptible to apical proliferation of epithelium and subsequent pocket formation.

However, Main et al. (2004) demonstrated that the use of MTA for repair of infected furcal perforations resulted in normal tissue architecture adjacent to the repair site after 1 year. According to the authors, the availability of MTA may require re-evaluation of previous guidelines regarding prognosis of perforated teeth.
Surgical Management of Perforation Defects

Whenever possible, nonsurgical repair is preferred in the management of perforations. An internal approach is usually less invasive and preserves the periodontal tissues. However, there are cases in which surgical intervention may be the treatment of choice. These include perforations in areas only accessible via surgery, perforations with a concomitant periodontal component, perforations that have not responded favorably to conservative therapy, and defects in which excessive amounts of a foreign body, such as obturating material, have been extruded (Regan et al., 2005).

In addition, there may also be ecologic factors that could tip the balance in the decision of which treatment option serves the patient best. If the defect is readily accessible surgically, and if disassembly of the existing coronal restoration would yield a significant risk and additionally high cost to the patient, then surgical repair may be considered. Some patients are treated best with a combination of a nonsurgical and surgical approach.

As a last resort, intentional replantation may be carried out in conjunction with perforation repair (Poi et al., 1999; Shuman et al., 1999).

43.17 Perforation of a fixed bridge abutment
Left: Radiograph showing a perforation by a misaligned post in an abutment tooth.
Middle: Sinus tract as a sign of apical periodontitis.
Right: Sinus tract traced with a gutta-percha cone. Because an internal approach to repair the perforation would have required disassembly of the four-unit bridge, surgical intervention was proposed (courtesy of Dr. Aye Min).

43.18 Surgical repair of the perforation
Left: Following flap reflection and osteotomy, access was gained to the perforation site.
Middle: Root resection carried out at the level of the perforation.
Right: Root tip preparation completed to a depth of 3 mm (courtesy of Dr. Aye Min).

43.19 Follow-up
Left: Postoperative radiograph shows the MTA root tip filling.
Middle: One-year follow-up radiograph showing complete resolution of the lesion.
Right: Four-year follow-up radiograph, showing complete healing of the lesion, indicating that the patient is completely asymptomatic (courtesy of Dr. Aye Min).