Dental Emergencies: A Practical Guide

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Abbreviations: PLS = periodontal ligament space, 3D = three-dimensional

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Recognize the most frequent causes of dental emergencies.
- Describe the imaging findings of the most common types of odontogenic infection, dental trauma, and dental procedure complications.
- Identify imaging hallmarks and pitfalls of dental emergencies.

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Dental disease is a frequent finding on head and neck images, especially in the context of emergencies, and can be a challenge for radiologists who are inexperienced with findings of dental trauma or disease. Dental abnormalities can be subtle and therefore must be included in the systematic approach to these images. Although dedicated dental images are not acquired in most emergency cases, the teeth are included on many different images of the head and neck, and their initial evaluation seldom requires a specific protocol. The high prevalence of craniofacial trauma, sinus infection, and maxillomandibular procedures, among other conditions, frequently requires interpretation of dental images in daily emergency practice. The imaging findings can be categorized into infection, trauma, and complications of procedures, although sometimes these categories can overlap. Such categories can help the radiologist decide which imaging protocol and dynamic maneuvers should be used and are also useful when reading images and proposing differential diagnoses. Familiarity with the imaging findings of dental emergencies improves the radiologist's diagnostic confidence and role in guiding patient care, avoiding progression to life-threatening conditions, and reducing aesthetic problems, dental loss, and related conditions. Information about the imaging protocols is provided, the relevant anatomy of the teeth and related structures is reviewed, and the key imaging findings of dental emergencies are presented.

Introduction

Dental emergency is a common problem observed in hospital emergency departments. Over the past decades, there has been a rise in emergency department visits for dental problems in the United States (1). Pain, trauma, and infection are among the most common concerns during such visits. For the most part, dental emergencies are not life threatening but can be painful and/or cosmetically significant (2).

Dental disease is a frequent finding on head and neck images, especially in the context of emergencies (2), and can be a challenge for the radiologist who is inexperienced with findings of dental trauma or disease. Dental abnormality can be subtle and therefore must be included in the systematic approach to these images (3). Although dedicated dental images are not acquired in most emergency cases, the teeth are included on many different images of the head and neck. Their initial evaluation seldom requires a specific protocol.

In this article, the imaging findings are categorized into infection, trauma, and complications of procedures, although sometimes these categories can overlap. They can help the radiologist decide which imaging protocol should be used and are also useful when reading images and proposing differential diagnoses. The goal of this article is to provide information about the imaging protocols, review relevant anatomy of the teeth and related structures, and present key imaging findings of dental emergencies.

TEACHING POINTS

- In the context of dental infection, the most indicated maneuver is the "puffed cheek" technique, which the patient performs by pursing the lips and puffing out the cheeks. This maneuver distends the oral cavity and separates the gingival and buccal mucosal surfaces, helping to more accurately locate mucosal lesions and small abscesses.
- It is essential to understand the route of dissemination of dental infections into the deep spaces of the neck. Their spread usually depends on their position relative to the mylohyoid line, which represents the attachment of the mylohyoid muscle to the mandible.
- In particular, unilateral maxillary sinusitis is highly indicative of odontogenic sinusitis; more than 70% of these cases can be attributed to dental disease.
- Luxation is the most common traumatic dental injury in the primary dentition, whereas crown fracture is most frequently reported in the permanent teeth. The maxillary incisors are the teeth most affected by traumatic injury.
- Infection related to a dental implant may lead to "peri-implantitis," a condition in which peri-implant osteolysis can threaten the hold of a dental implant, often associated with inflammation of adjacent soft tissues.

Imaging Protocols

The role of the radiologist begins with selection of the most appropriate imaging protocol. This is an essential step in the process and is necessary for an accurate diagnosis.

Cone-beam CT allows evaluation of the teeth and alveolar bone with high spatial resolution, three-dimensional (3D) images, and less radiation exposure compared with multidetector CT. Its main drawback is poor image quality of soft tissues and limited availability in emergency centers. In most cases, multidetector CT is the modality of choice to help evaluate dental emergencies because of its wide availability, scanning speed, and high spatial resolution (4,5). The obtained image sections should be as thin as possible to allow identification of subtle abnormalities. Isotropic datasets, when available, permit reformation into axial, coronal, and sagittal planes, as well as 3D surface-rendered and panoramic reconstructions that can be of great value during image interpretation (3,6). Contrast-enhanced images improve the evaluation in cases of suspected infection or in investigations of active bleeding after a dental procedure (7).

Some dynamic maneuvers provide more image details and thus enhance accuracy. In the context of dental infection, the most indicated maneuver is the "puffed cheek" technique, which the patient performs by pursing the lips and puffing out the cheeks. This maneuver distends the oral cavity and separates the gingival and buccal mucosal surfaces, helping to more accurately locate mucosal lesions and small abscesses (Fig 1) (8). If metal artifacts degrade images of the oral cavity, another technique that may be useful is to acquire images with the mouth closed and open, therefore moving the metal artifacts to a different area in the second acquisition (8).

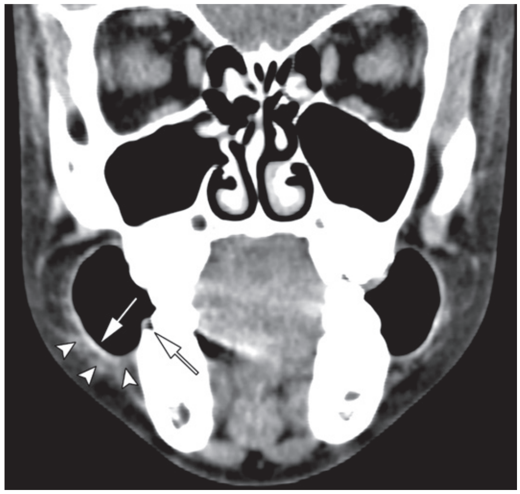


Figure 1. Puffed cheek technique. Coronal nonenhanced CT image (soft-tissue window) shows the oral cavity distended by air, with mucosal thickening (arrows) and subcutaneous edema (arrowheads), which could be difficult to depict without the technique.

Anatomy and Nomenclature

The tooth is formed by two main parts composed of different tissues. The portion that can be observed at oral inspection is called the crown, while the portion covered by the alveolar bone ridge is called the root. The crown is composed of two mineralized layers (one external harder layer, called enamel, and a deeper layer, called dentin) and an inner structure known as pulp. The dentin and pulp extend apically and form the root, which is surrounded by a thin layer of cementum, a third mineralized layer (Fig 2). The pulp contains the neurovascular elements (9). The transition between enamel and cementum marks the boundary between crown and root and is named the cementoenamel junction or neck (10).

The teeth are attached in bone sockets called alveolar processes and are fixed to these cavities by ligaments called periodontal ligaments that exert a damping role, allowing slight mobility during chewing.

Human dentition develops in two overlapping stages, resulting in formation of two dental sets that are called primary and secondary dentition. The primary set, also known as deciduous, is composed of 20 temporary teeth that begin to erupt at 6 months of age and are shed by about 12 years of age, giving rise to a secondary set of 32 permanent teeth that begin to appear around 7 years of age (3,10,11).

Extending distally from the midline, the quadrants of the primary teeth are named as follows:

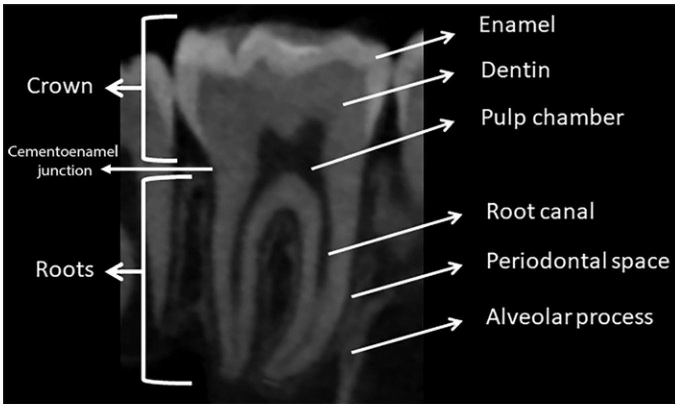


Figure 2. Tooth anatomy. Sagittal cone-beam CT image demonstrates the two main parts of the tooth and its layers, attached to the alveolar process.

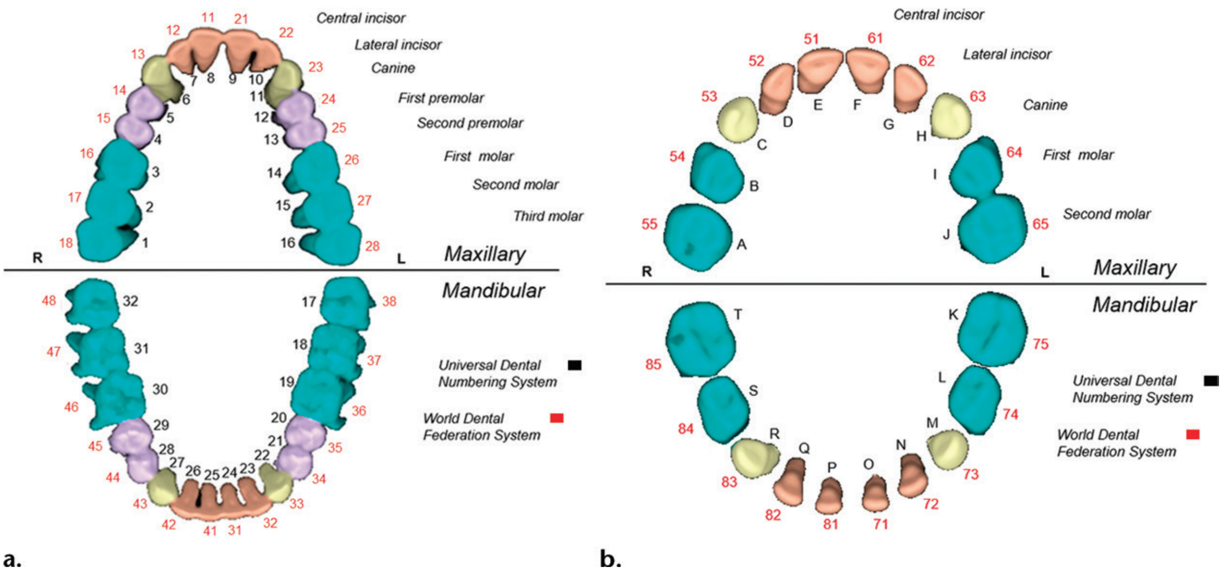


Figure 3. Tooth numbering and nomenclature. Color reconstruction of a 3D volume-rendered CT image shows the Universal Dental (black) and World Dental Federation (red) numbering systems and dental nomenclature for the permanent **(a)** and deciduous **(b)** dentition.

central incisor, lateral incisor, canine, first molar, and second molar. In the permanent dentition, the teeth are named as follows: central incisor, lateral incisor, canine, first premolar, second premolar, first molar, second molar, and third molar (Fig 3) (10).

The teeth can be numbered by two major classification systems: the Universal System and the World Dental Federation System (3). Despite its name, the Universal System is most commonly used in the United States. In this system, the upper right, upper left, lower left, and lower right quadrants are arranged in a circle in the clockwise direction. This system identifies the primary teeth with letters in alphabetical order, progressing from A to T clockwise, and the permanent teeth with numbers, from 1 to 32, also clockwise.

The World Dental Federation System is better known globally and uses a combination of two numbers, the first of which indicates the quadrant of the tooth and the second number the position of the tooth in each respective quadrant. Thus, the upper right, upper left, lower right, and lower left quadrants receive the numbers 5, 6, 7, and 8 in the primary dentition and 1, 2, 3, and 4 in the permanent dentition. The second number refers to the position of the tooth from medial to lateral, ranging from number 1 (central incisor) to number 5 (second molar) in the primary dentition and to number 8 (third molar) in the permanent dentition (Fig 3) (11).

Infections

Odontogenic infection arises from any part of the tooth or adjacent structures and can directly spread into adjacent bone and soft tissues through superficial and deep neck spaces. Imaging plays a crucial role in identifying the source of infection and the extent of the disease process, as well as depicting any complications.

It is essential to understand the route of dissemination of dental infections into the deep

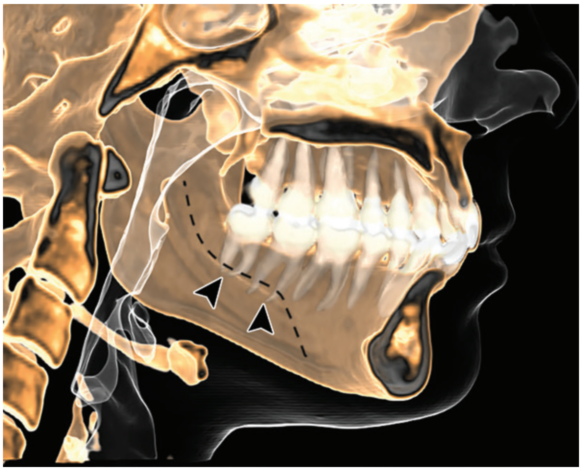
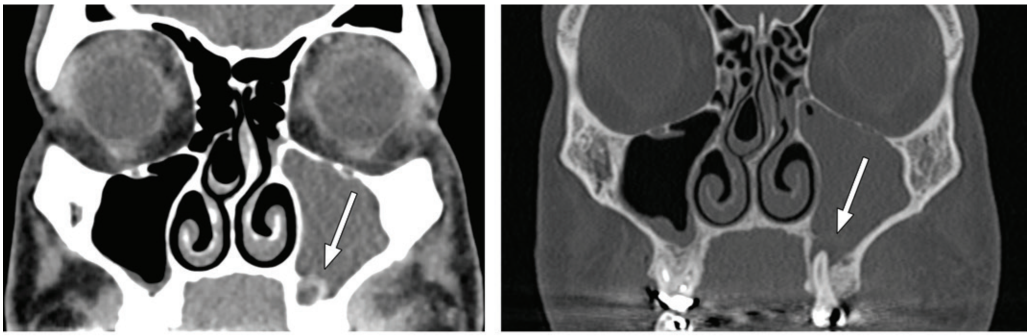


Figure 4. Mylohyoid line. Three-dimensional volume-rendered CT image shows the attachment of the mylohyoid muscle to the internal surface of the mandible (dashed line). It lies above the root apices of the second and third molars (arrowheads) and below the root apices of the other teeth. (Courtesy of Fábio Augusto Ribeiro Dalprá, MD, Hospital Israelita Albert Einstein, São Paulo, Brazil.)



a. b.

Figure 5. Periapical abscess. **(a)** Coronal contrast-enhanced CT image (soft-tissue window) demonstrates a hypoattenuating fluid collection with peripheral enhancement (arrow). **(b)** Coronal CT image (bone window) shows bone loss around the root apex with discontinuity of the maxillary sinus floor (arrow). Both images show complete opacification of the left maxillary sinus, consistent with odontogenic sinusitis.

spaces of the neck. Their spread usually depends on their position relative to the mylohyoid line, which represents the attachment of the mylohyoid muscle to the mandible. The mylohyoid line divides the submandibular and sublingual spaces, so that lesions involving the root apices of the second and third molars disseminate directly to the submandibular space, while lesions involving other teeth disseminate to the sublingual space (Fig 4) (4,12).

Periapical and Subperiosteal Abscesses

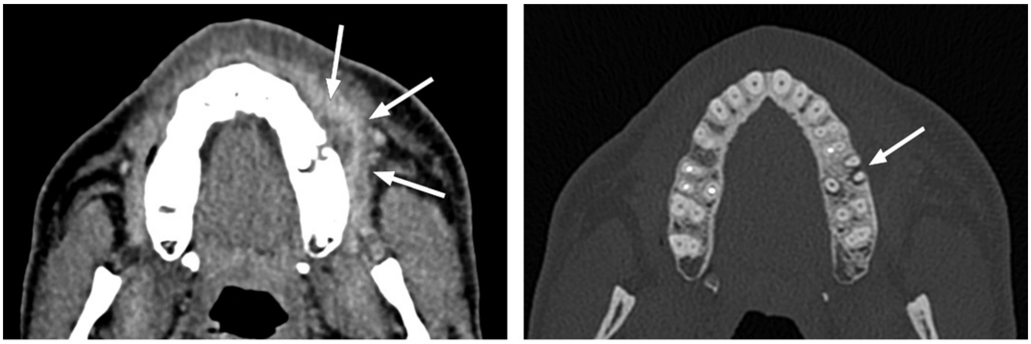
Inflammation of periapical tissues is caused by infection of the root canal with pulp devitalization, arising from carious lesions on the crown (12). Widening of the periodontal space adjacent to the root apex leads to bone erosion and produces periapical lucency, which can be observed on radiographs and CT images. Periapical abscess is the organized infection of apical periodontitis. When prolonged, this condition increases bone erosion and can lead to cortical discontinuity and spread of infection beyond the alveolar bone (6).

When this process arises from the upper dental arch with rupture of the cortical bone, the infection can extend into the overlying maxillary sinus, sometimes causing odontogenic sinusitis, which can progress to an abscess inside the sinus (Fig 5). When the infection progresses with rupture of the cortical bone, it usually penetrates along the bone margin and extends as an extraosseous abscess, either confined by the periosteum, forming a subperiosteal abscess (Fig 6), or disseminating into deep neck planes (6).

Pericoronitis

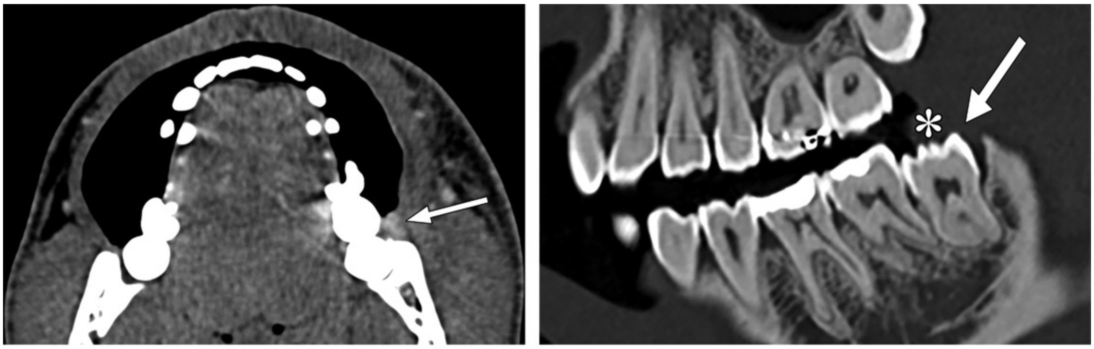
Pericoronitis is the inflammation around the crown of a partially erupted tooth, affecting the pericoronal tissue, most commonly in the mandibular third molars (12).

Those teeth usually erupt without opposition, thus being more prone to the impaction of food particles between the gingiva and crown, which forms a source of infection and inflammation. The process manifests initially with local gingivitis and can spread to the surrounding tissues, including the alveolar bone or even culminating in abscess formation (2). At imaging, pericoronitis typically appears as thickening and enhancement of the pericoronal tissues of a partially erupted tooth (Fig 7).



a. b.

Figure 6. Subperiosteal abscess. **(a)** Axial contrast-enhanced CT image (soft-tissue window) shows a hypoattenuating fluid collection with peripheral enhancement and stranding of the adjacent fat tissues (arrows). **(b)** Axial CT image (bone window) demonstrates that the collection is continuous with periapical disease and erosion of the vestibular cortical bone (arrow).



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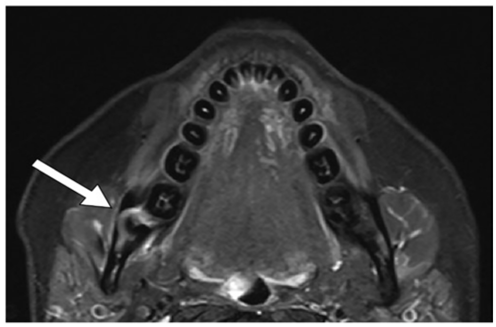


c.

Figure 7. Pericoronitis. **(a)** Axial contrast-enhanced CT image (soft-tissue window) demonstrates enhancement of the pericoronal tissues (arrow). **(b)** Sagittal CT image (bone window) shows that the affected tooth is partially erupted (arrow) and partially covered by gingiva (*). **(c)** Axial contrast-enhanced T1-weighted MR image in a different patient also reveals pericoronal enhancement (arrow).

Odontogenic Sinusitis

Odontogenic sinusitis substantially differs from sinusitis of other causes in its pathophysiology, microbiology, and treatment. Injury of the mucoperiosteum of the maxillary sinus is the basis of odontogenic sinusitis pathophysiology. Dental procedures are considered to be the most common cause of odontogenic sinusitis, followed by periapical and periodontal disease (13).

On images, the diagnosis is made when an interruption of the maxillary sinus floor, frequently associated with periodontal or carious disease, is associated with sinusitis (Fig 8). In particular, unilateral maxillary sinusitis is highly indicative of odontogenic sinusitis; more than 70% of these cases can be attributed to dental disease (14,15). Anaerobic bacteria are more frequent in odontogenic sinusitis than in nonodontogenic sinusitis, which warrants a different treatment approach (16,17). Furthermore, because the mucoperiosteum and mucociliary function are compromised in odontogenic sinusitis, endoscopic sinus surgery may be required in addition to treatment of the dental condition (18).

Ludwig Cellulitis

Ludwig cellulitis, also called Ludwig angina, is infectious cellulitis of the subcutaneous and deep neck spaces that extends bilaterally, generally involving the sublingual, submental, and submandibular spaces (Fig 9) (19). The infection more commonly arises from the second and third mandibular molars, although it can originate from any other oral or adjacent infected structures. It is more frequent in patients in an immunocompromised state or in individuals with other comorbidities, such as diabetes mellitus and hypertension (20,21). The potential risk of airway obstruction

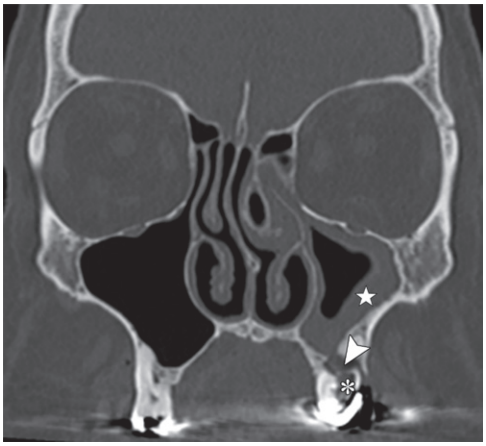
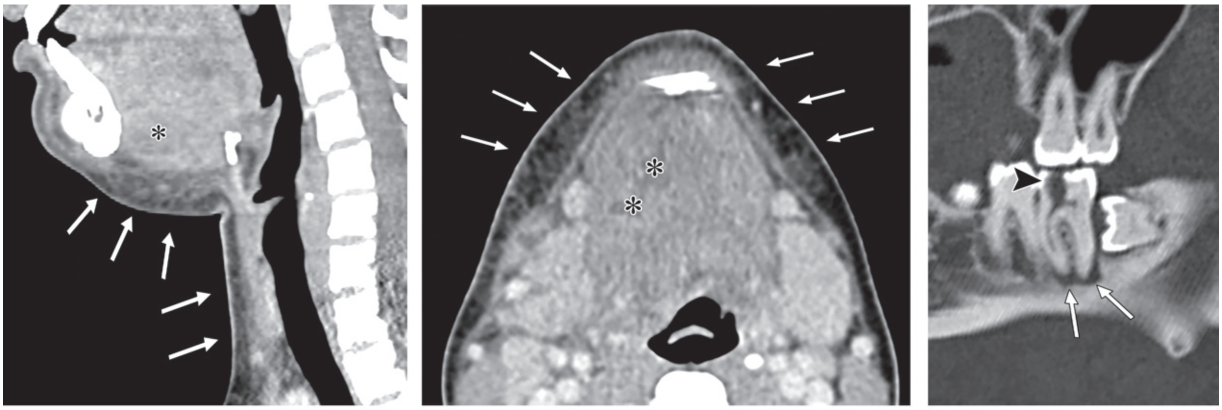


Figure 8. Odontogenic sinusitis. Coronal nonenhanced CT image (bone window) demonstrates unilateral maxillary sinusitis (☆) associated with a bone discontinuity that communicates the sinus floor with periodontal disease (arrowhead) around a tooth with a large carious lesion (*).



a. **b.** **c.**

Figure 9. Ludwig cellulitis. **(a, b)** Sagittal **(a)** and axial **(b)** contrast-enhanced CT images (soft-tissue window) reveal a small fluid collection with peripheral enhancement (*), with fat stranding and edema extending bilaterally within the submandibular, sublingual, and submental spaces (arrows). **(c)** Sagittal CT image (bone window) demonstrates a carious lesion affecting the pulp chamber (arrowhead) of the lower second molar with apical periodontitis (arrows), therefore revealing the cause of the infectious process.

Figure 10. Chronic osteomyelitis of the mandible. Axial nonenhanced CT image (bone window) demonstrates a sequestrum (arrow), periosteal reaction (white arrowhead), and linear bone radiolucencies consistent with a sinus tract (black arrowheads).

due to the rapid spread of the cellulitis makes this condition life threatening, requiring prompt evaluation. CT is useful for diagnosis and to determine airway patency, the source of infection, and the presence of drainable abscesses (7,19).

Osteomyelitis

Osteomyelitis of the jaw is most often caused by a bacterial focus that can originate from an odontogenic infection (periapical or periodontal lesion), surgical site, foreign body, or fracture (12). It occurs more commonly in the mandible, as the maxilla has significant collateral blood flow and bone marrow with struts that make it less prone to infection (22,23).

The first signs of osteomyelitis are bone marrow edema and loss of the trabecular structure, which can progress to fragmentation of the cortices and spread of the infection to adjacent soft parts (12,24). In the acute phase, there is predominantly bone lysis, whereas in the chronic phase, more sclerosis of trabecular bone occurs. A sequestrum is characteristic of chronic osteomyelitis and represents a segment of necrotic bone that is separated from living bone by granulation tissue and bone resorption (Fig 10) (25,26).

CT is the best modality for assessing fine bone detail, periosteal bone formation, the sequestrum, and the source of infection; however, bone marrow

Figure 11. Acute osteomyelitis of the mandible. Axial T1-weighted **(a)**, T2-weighted **(b)**, and contrast-enhanced T1-weighted **(c)** MR images demonstrate signal intensity changes and enhancement of the bone marrow of the mandible (*).

changes are not well depicted with this method. Compared with CT, MRI has worse spatial resolution; however, it is the modality of choice for depicting bone marrow edema in the early stages, which appears as high signal intensity on T2-weighted and short τ inversion-recovery (STIR) images. On T1-weighted images, low signal intensity of the affected areas reflects loss of normal fatty marrow signal (Fig 11) (26). Soft-tissue extension, abscess formation, and sinus tracts are also accurately depicted on MR images (12,25,27).

Imaging is used in osteomyelitis to help the radiologist localize the condition, determine its source and extent, and evaluate response after treatment.

Dental Trauma

Dental trauma is extremely common, with approximately one-third of all individuals experiencing a dental injury during their lifetime (28). Dental trauma can be classified into fracture, luxation, and avulsion (29,30). Luxation is the most common traumatic dental injury in the primary dentition, whereas crown fracture is most frequently reported in the permanent teeth (31). The maxillary incisors are the teeth most affected by traumatic injury (2,32).

A fracture is a discontinuity of any dental component and can result in loss of tooth structure. It can be classified according to the affected segment of the tooth: crown, crown-root, and root fractures. It is fundamental to assess the extent of the fracture through the tooth layers (Figs 12–14), since fractures affecting the pulp (pulp chamber or root canal) place the tooth vitality at risk and thus carry a worse prognosis. When the fracture involves the alveolar process, it is called a dentoalveolar fracture.

Dental luxation is a general term that covers multiple types of injuries to the tooth support structures, particularly the periodontal ligament. Dental luxation injuries are divided into concussion, subluxation, extrusive luxation, intrusive luxation,

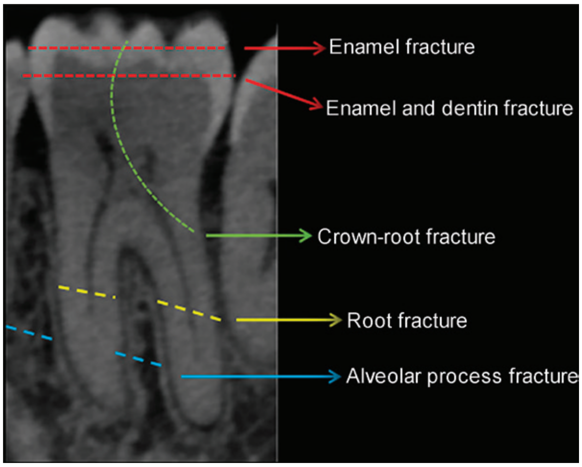


Figure 12. Dental fractures. Cone-beam CT image of a molar tooth shows lines representing different types of dental fractures.

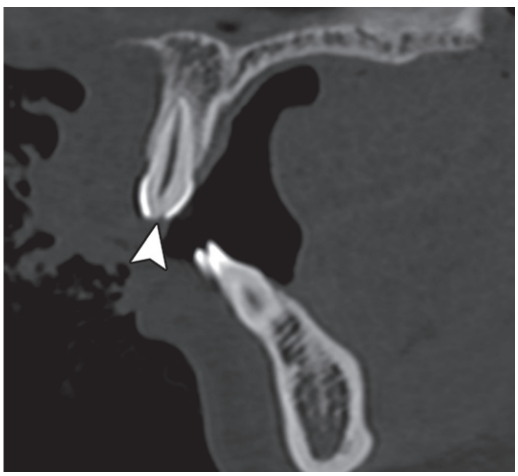


Figure 13. Dental crown fracture. Sagittal CT image (bone window) shows a fracture of enamel and dentin without pulp involvement (arrowhead).

and lateral luxation (Table, Fig 15). They can be associated with dental fracture but can also manifest without dental fracture.

While radiologic abnormalities are not expected in concussion and subluxation, tooth displacement

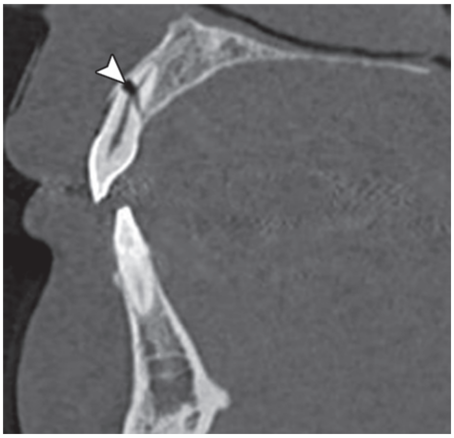


Figure 14. Dental root fracture. Sagittal CT image (bone window) shows a root fracture with pulp involvement (arrowhead).

Clinical Manifestation and Imaging Findings of Luxation and Avulsion Injuries

Type of Injury	Clinical Manifestation	Imaging Findings	Figures
Concussion	Tooth is tender to touch, without loosening or displacement	No abnormalities	15a
Subluxation	Tooth is tender to touch, with loosening but no displacement	Abnormalities are not expected	15a
Extrusive luxation	Tooth appears longer and displaced, with marked loosening	Widening of PLS,* usually in apical region	15b, 16
Lateral luxation	Tooth is displaced, without loosening	Asymmetric widening of PLS with fracture of alveolar bone	15c, 17
Intrusive luxation	Tooth is displaced into alveolar bone	Tooth intrusion into alveolar bone, PLS reduced or absent	15d
Avulsion	Tooth is completely out of socket	Empty socket	15e

*PLS = periodontal ligament space.

and widening of the periodontal ligament space (PLS) are observed in extrusive luxation (Fig 16) and lateral luxation (Fig 17), the latter accompanied by fracture of the alveolar process. Despite its name, lateral luxation consists of eccentric displacement of the tooth, usually in the palatal, lingual, or labial direction. On the other hand, intrusive luxation appears on images as a narrowed or absent PLS, with a tooth displaced into the alveolar bone (Table) (29,33,34).

A potential pitfall to be aware of is that a widened PLS can develop in patients receiving orthodontic treatment, usually in multiple teeth, mimicking extrusive luxations (35). In these cases, the brackets and wires are easily seen on CT images and radiographs.

Finally, *avulsion* is the term used when the tooth is completely displaced from the alveolar socket (Fig 18) (30,36).

Complications of Dental Procedures

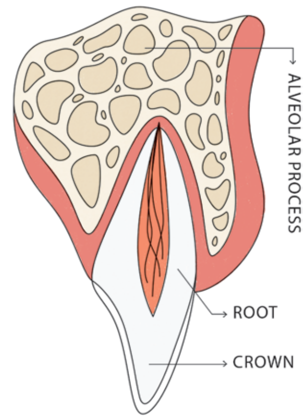
Complications of dental procedures are widely seen in daily practice. Some complications may require imaging assessment, and the radiologist must be prepared to evaluate them. To better understand the imaging findings, it is essential to ask the patient about the specific procedure that was previously performed and when. Knowledge of the elapsed time between procedure and imaging examination is also useful to help determine the type of lesion.

Complications of Tooth Extraction

The main reasons for extraction of permanent teeth are caries, periodontal disease, and dental impaction, the latter mainly involving the third molars, also called wisdom teeth (37). Postoperative complications after tooth removal may range from mild discomfort to major complications requiring hospitalization or resulting in permanent damage (38).

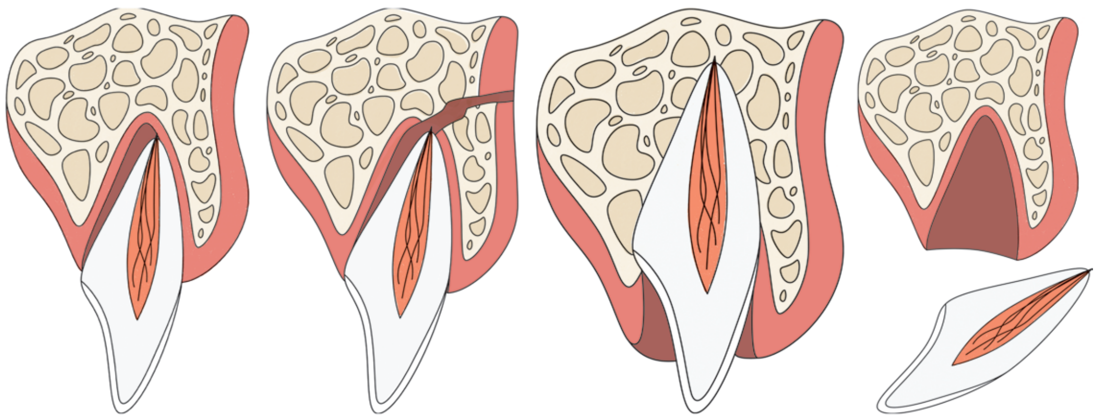
Typical imaging findings in the first few days after a noncomplicated dental extraction are soft-tissue material filling the tooth socket (often with gas bubbles) and thickening and stranding of the adjacent tissues, mainly the gingiva, buccal mucosa, and buccal space. These structures are better depicted with the puffed cheek technique on multidetector CT images (Fig 19) (39).

Infection is among the most common complications after tooth extraction (40). It may spread



a.

Figure 15. Types of dental luxation and avulsion injuries. Normal tooth appearance, similarly seen in concussion and subluxation **(a)**, as well as extrusive luxation **(b)**, lateral luxation **(c)**,intrusive luxation **(d)**, and avulsion **(e)**.



b. c. d. e.

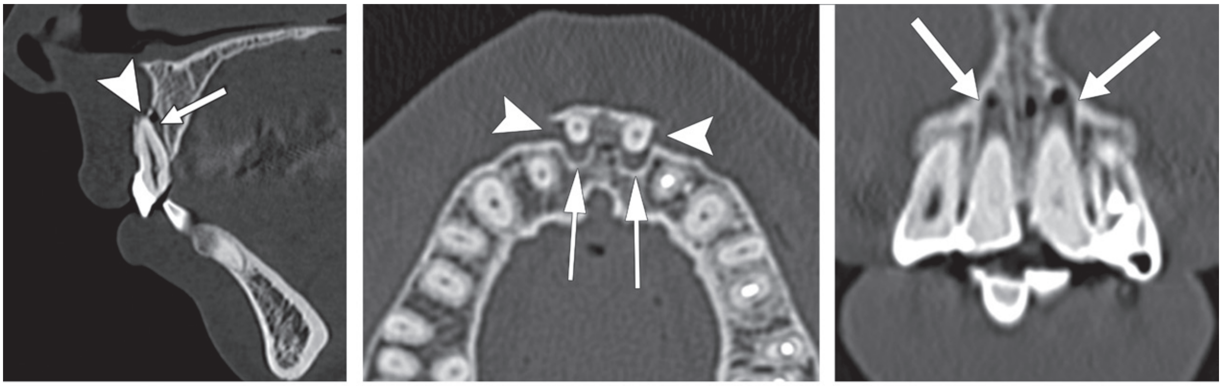
a. b. c.

Figure 16. Dental extrusive luxation. Sagittal **(a)**, axial **(b)**, and coronal **(c)** CT images (bone window) show tooth displacement with widening of the PLS (arrows).

from the surgical site to the adjacent tissues and lead to development of cellulitis, abscess, and even life-threatening deep neck infection. It usually manifests as an increase in facial or neck swelling beyond the 3rd or 4th postoperative day, with increasing pain. In these cases, stranding and thickening of the adjacent tissues are more widespread (Fig 20), with the parapharyngeal, submandibular, anterior visceral, masticator, and sublingual spaces being the most involved (3). Abscess appears as a fluid collection with rim enhancement. If the infection spreads into the medullary alveolar bone, osteomyelitis may develop.

Noninfectious complications include traumatic displacement of an impacted tooth (either a fragment or the entire tooth) (Fig 21), bone fracture (Fig 22), hematoma, and oroantral fistulas.

Hematoma may be associated with a focus of active bleeding, which can be observed at contrast-enhanced CT as an area of extravasation near the extraction site, often inside the tooth socket (Fig 23).



a. b. c.

Figure 17. Dental lateral luxation. Sagittal **(a)**, axial **(b)**, and coronal **(c)** CT images (bone window) show tooth displacement, widening of the PLS (arrows), and fracture of the alveolar process (arrowheads in **a** and **b**).

Figure 18. Dental avulsion. Sagittal CT image (bone window) shows an empty alveolar socket (*).

Figure 20. Cellulitis after third molar extraction. Axial contrast-enhanced CT image (soft-tissue window) a few days after left inferior third molar extraction (*) shows thickening of the gingival and buccal mucosa, masseter muscle, and perimandibular soft tissues, with gas bubbles and extensive stranding of the subcutaneous fat (arrows).

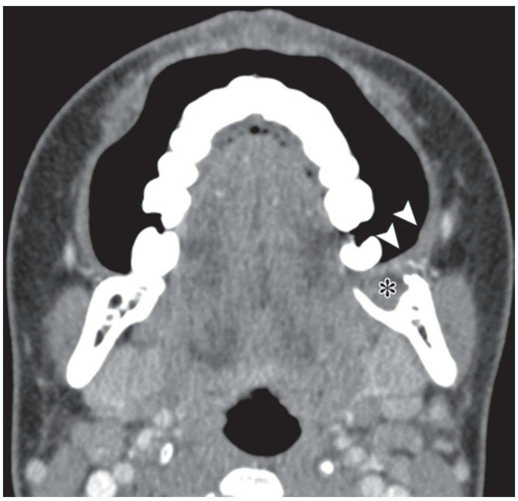


Figure 19. Noncomplicated third molar extraction. Axial contrast-enhanced CT image (soft-tissue window) a few days after a dental extraction shows soft-tissue material filling the alveolar cavity (*), thickening and enhancement of gingival and buccal mucosal surfaces (arrowheads), and mild stranding of the buccal fat space.

Oroantral fistula is an abnormal defect of the maxillary sinus floor, communicating the antrum with the oral cavity. It can be a complication of tooth extraction, most commonly of the maxillary molars (41). At imaging, identification of bony disruption of the maxillary sinus floor is usually straightforward.

However, soft tissue (gingival mucosa, granulation tissue, or debris) is often observed to obliterate the tooth socket. A final diagnosis of oroantral fistula might be difficult. The puffed cheek technique separates the buccal and gingival mucosa (39,42) and, in our experience, makes it easier to detect an air passageway between the maxillary sinus and oral cavity (Fig 24). A swish of water-soluble iodinated contrast medium before acquisition of CT images can also be useful. Diagnosis of oroantral fistula is made when contrast medium is identified inside the maxillary sinus (43).

Presurgical imaging is useful to evaluate the relationship between the tooth and maxillary

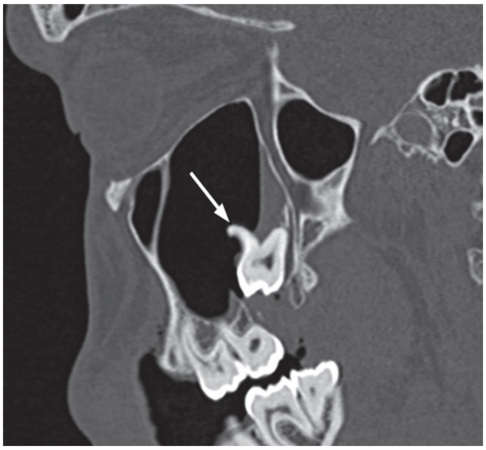


Figure 21. Traumatic tooth displacement. Sagittal nonenhanced CT image (bone window) shows a third molar (arrow) displaced into the maxillary sinus.

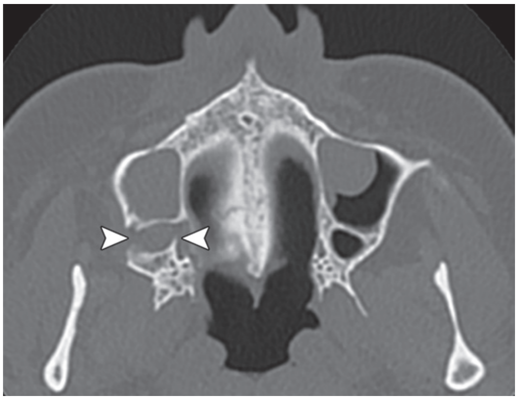


Figure 22. Bone fracture. Axial nonenhanced CT image (bone window) after third molar extraction shows fracture of the right maxillary sinus floor (arrowheads).

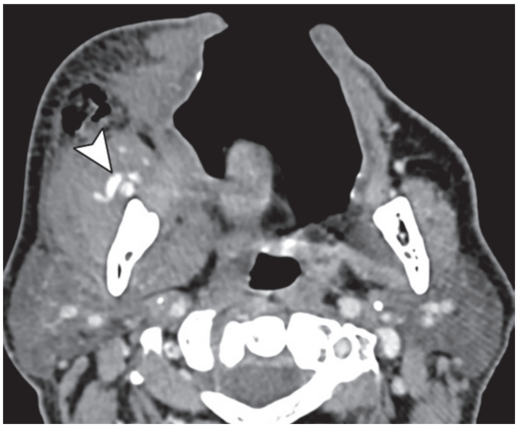


Figure 23. Hematoma with active bleeding. Axial contrast-enhanced CT image (soft-tissue window) after third molar extraction shows a large hematoma containing serpentine foci with enhancement (arrowhead).

Figure 24. Oroantral fistula. Coronal nonenhanced CT image (bone window) demonstrates a bony defect connecting the left maxillary sinus floor with the oral cavity. The puffed cheek technique made diagnosis possible by separating the adjacent soft tissues and filling the fistulous tract with air (arrow).

sinus floor, as well as the thickness of the alveolar process, which may indicate a higher risk of fistula formation. When the connection is less than 2 mm wide, it usually heals spontaneously. Larger interruptions may require surgical intervention (3,44).

Complications of Dental Implants

Dental implants are the best long-term substitute for missing teeth and have become very popular over the past few decades because they restore nearly normal function in partially or completely edentulous patients (45). Most implants are composed of a metallic hollow supporting screw that receives a supraprosthetic device after a healing period for osseointegration (46). Dental implants are readily observed at CT using a bone window, as well as at radiography (45).

Patients must have sufficient bone volume in the jaw to anchor implants and to avoid damaging surrounding structures, in particular the mandibular canal and maxillary sinus. Bone graft materials can be used to increase the height and thickness of the alveolar bone.

Maxillary sinus augmentation (also known as sinus floor elevation) procedures have become increasingly popular before placement of dental implants. They are used when the alveolar bone of the maxilla is thin owing to alveolar bone atrophy, sinus pneumatization, or trauma (47).

On CT images, the bone graft material used to augment the alveolar process appears as irregular masses of high attenuation similar to bone in the inferior half of the maxillary sinus, which may lead to misdiagnosis as bone lesions such as fibrous dysplasia and osteoma. Failure of these procedures may result from infection and lack of integration of the graft material into the alveolar bone, usually accompanied by graft fragmentation (45). Bone graft fragments inside the maxillary sinus may mimic fungal sinusitis, in which case the clinical history is essential to distinguish between these two conditions (Fig 25).

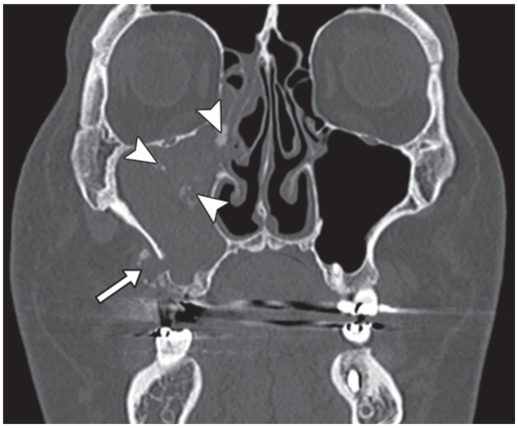
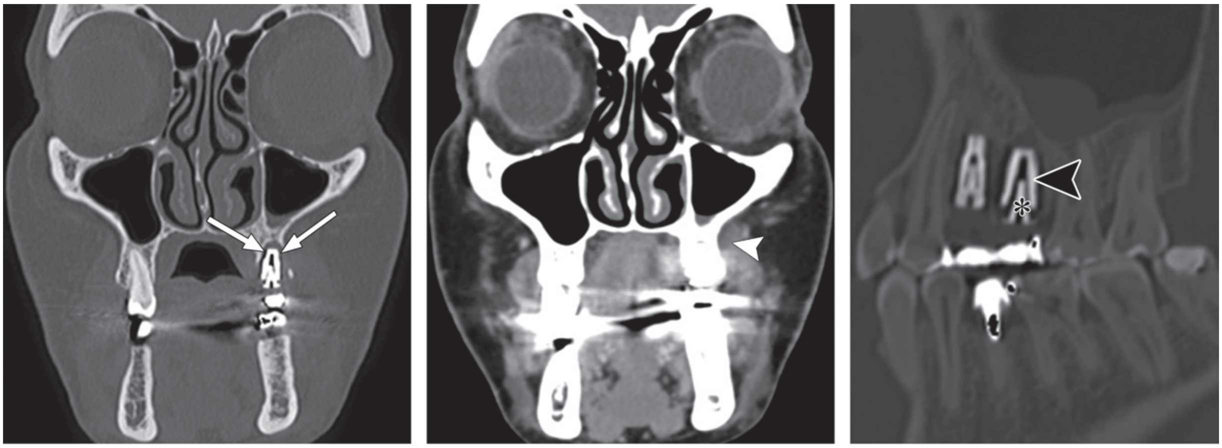


Figure 25. Bone graft fragmentation. Coronal nonenhanced CT image (bone window) shows complete opacification of the right maxillary sinus. The bone graft material is diffusely dispersed inside the sinus (arrowheads) and adjacent to a bony discontinuity at the maxillary sinus floor (arrow).



a. b. c.

Figure 26. Peri-implantitis. **(a)** Coronal nonenhanced CT image (bone window) demonstrates peri-implant bone resorption (arrows). **(b)** Coronal image (soft-tissue window) shows inflammatory changes of the adjacent soft tissues (arrowhead). **(c)** Sagittal image (bone window) shows loosening between the implant fixture (arrowhead) and abutment (*).

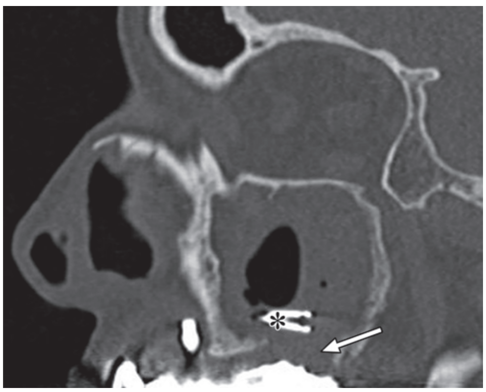


Figure 27. Dental implant dislodgement. Sagittal nonenhanced CT image (bone window) demonstrates a dental implant (*) dislodged into the maxillary sinus. There is also a large bone discontinuity of the maxillary sinus floor (arrow).

Poor osseointegration of dental implants can be detected on radiographs and CT images as radiolucent peri-implant areas. It can be a result of a foreign-body inflammatory reaction or infection, although the underlying cause is often not determined (48). Infection related to a dental implant may lead to "peri-implantitis," a condition in which peri-implant osteolysis can threaten the hold of a dental implant, often associated with inflammation of adjacent soft tissues (Fig 26) (49,50).

Dislodgement of an implant into the maxillary sinus can occur several days or even years after implantation or abutment connection surgery (Fig 27). This may occur because of positioning of an implant in an unnecessary apical position, excessive pressure during placement, or widening of the ridge due to overdrilling (47).

In addition to the maxillary sinus and mandibular canal (Fig 28), dental implants can damage other adjacent structures, such as the nasal cavity floor, mental foramen, incisive foramen, and nasopalatine canal (48).

Medication-related Osteonecrosis of the Mandible

Medication-related osteonecrosis of the mandible is related to use of bisphosphonates or other medications administered to inhibit bone turnover

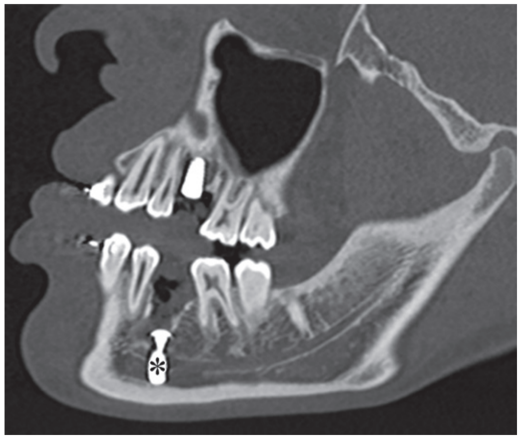


Figure 28. Dental implant dislodgement. Sagittal nonenhanced CT image (bone window) demonstrates a dental implant (*) dislodged into the mandibular canal.

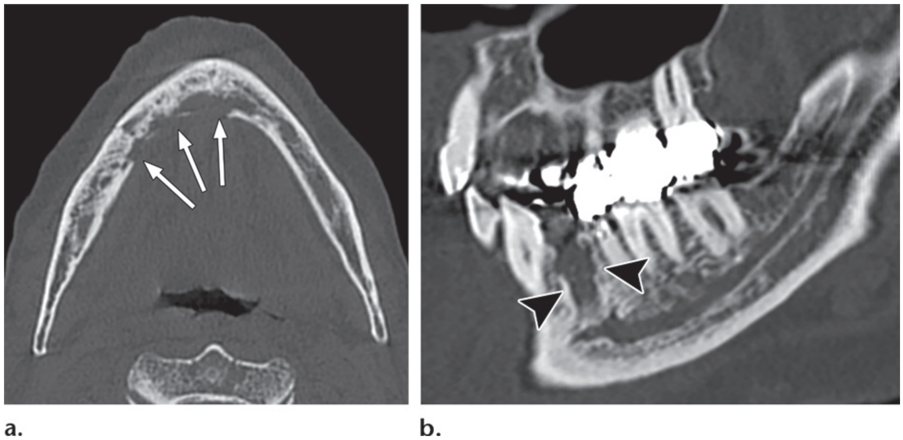


Figure 29. Medication-related osteonecrosis of the mandible. **(a)** Axial CT image (bone window) demonstrates sclerotic and lytic areas in the mandible with discontinuities of the cortical bone (arrows). **(b)** Sagittal CT image (bone window) reveals the nonhealing socket of an extracted tooth (arrowheads).

(51,52). It is characterized as a nonhealing area of exposed bone at trauma sites in patients who did not undergo craniofacial radiation therapy, more frequently in dental extractions. The risk of developing the disease is associated with the dose, duration, and potency of the drug used (51). It is usually painful but can be asymptomatic. Only a minority of cases affect the maxilla (22). Clinical findings define the diagnosis, but imaging is relevant to determine the extent of disease, exclude other diagnoses, and help evaluate complications, such as fracture (51).

Panoramic radiography, CT, and MRI are imaging modalities that can be used. The disease is characterized by bone sclerosis permeated by osteolytic areas, irregularity and destruction of cortical margins, and periosteal thickening (Fig 29). Examinations can also show the persistent alveolar tooth socket, bone sequestrum, pathologic fracture, fistula, or soft-tissue extension. In the early phases of the disease, CT usually shows a sclerotic bone area without corticomedullary differentiation around the extracted tooth socket or at the site of bone trauma. At MRI, signal intensity abnormalities can be variable depending on the stage of the disease, and it can better demonstrate the extent of disease compared with CT (51).

Conclusion

The high prevalence of craniofacial trauma, sinus infection disease, and maxillomandibular procedures, among other conditions, frequently requires interpretation of dental images in daily emergency practice. Teeth can be the source or the extension of a pathologic process and therefore must not be overlooked by radiologists when performing emergency imaging. Radiologists can use their knowledge of the main dental imaging findings in emergency radiology to add great value to image interpretation.

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