THIRD EDITION

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Diagnostic Imaging Oral and Maxillofacial

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Diagnostic Imaging
Oral and Maxillofacial

THIRD EDITION

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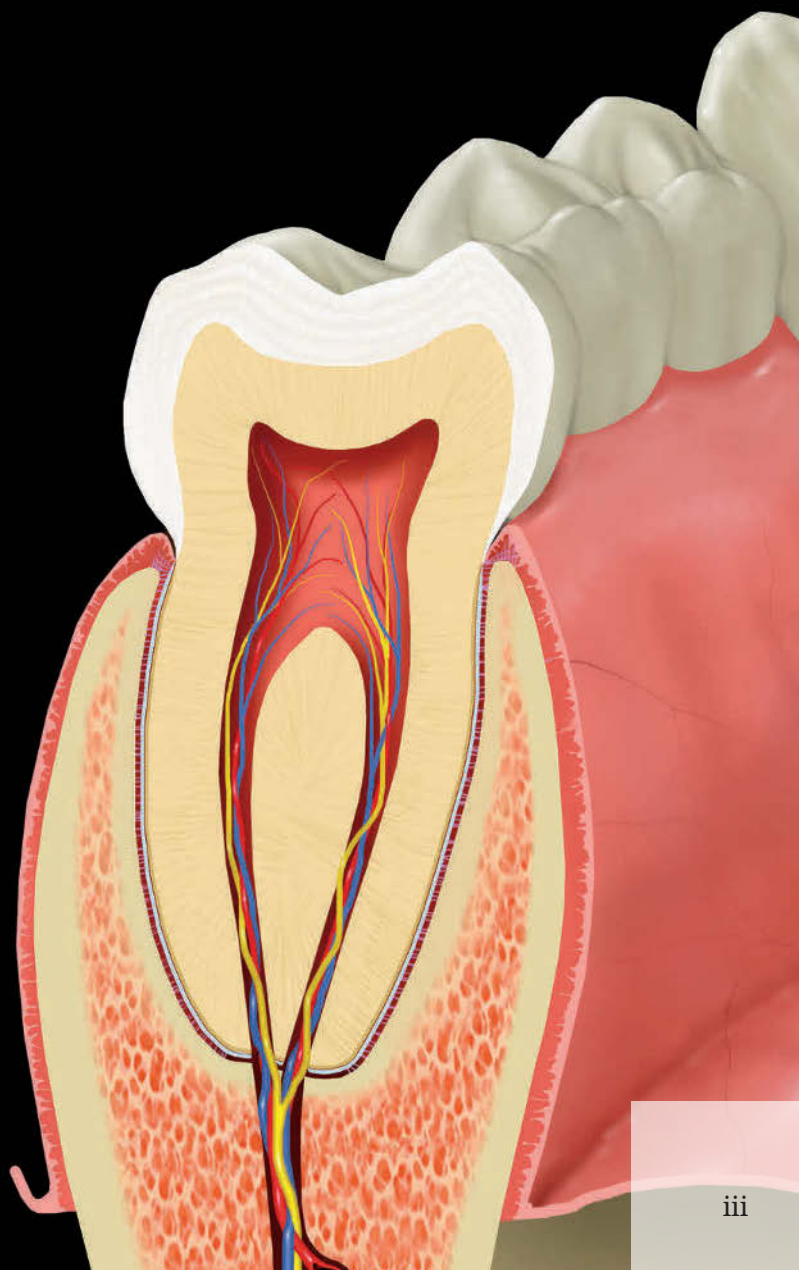

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Dedications

Thank you to my coauthors, Dania, Susanne, and Husniye, for taking on this task with me, and to the many colleagues who shared their images with us, especially Marcel Noujeim, who again gave generously.

To my grandchildren: Raphael, Will, Isla, Lucy, Halle, Freya, Ilse, and new baby Nora, who, along with my extended family and friends, fill my heart with joy. And to John: Thank you for your love and support, and for keeping me laughing these last two years.

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To all students and lovers of radiology, young and old. You are why we do this.

DT

For all the readers, who share our passion for oral and maxillofacial radiology and who embrace that the learning never stops.

For my colleagues and students, who help fuel that passion.

For my family, the meaning for everything.

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To my parents, Nermihan and Ismail: For everything! I hope I make you proud.

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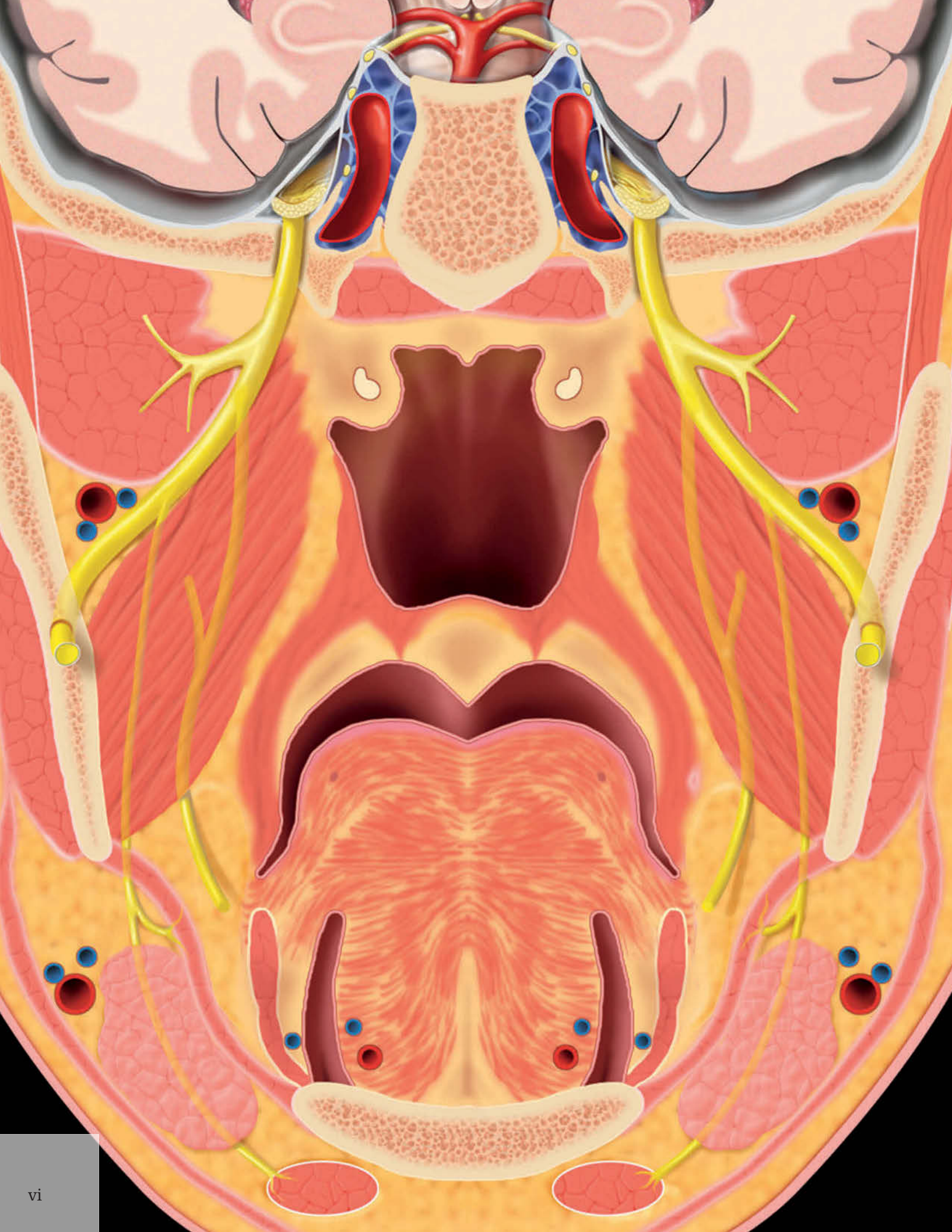
To my teachers and students: For being guiding stars that illuminate my path.

HD



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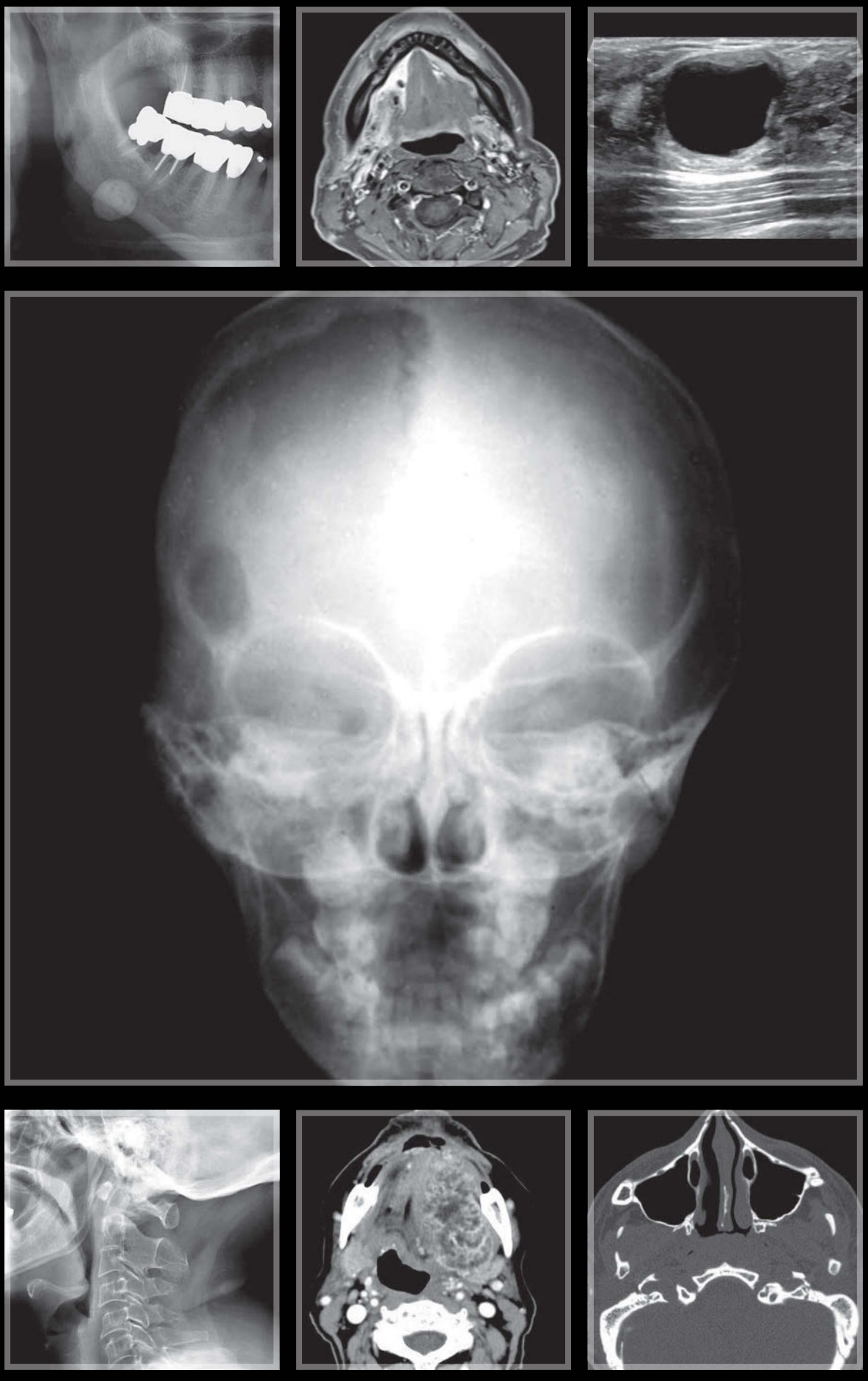

Preface

Welcome to the third edition of our *Diagnostic Imaging* text dedicated to oral and maxillofacial radiology. In this edition, you will see not only the anatomy, diagnoses, and differential diagnoses sections that you have come to expect, but also a new section on imaging applications in the oral and maxillofacial region. This new section includes chapters on artificial intelligence (AI) in oral radiology, an introduction to ultrasound (US) use in oral and maxillofacial diagnosis, and cone beam CT (CBCT) applications in implant dentistry, endodontics, orthodontics, and analysis of sleep-disordered breathing risks. There is also a new, heavily illustrated chapter on radiologic patterns of jaw disease that systematically takes the reader through the process of interpreting an image and making a diagnosis.

The Anatomy section has seen the addition of Skull Base and Cranial Nerves Overview chapters as well as chapters on cranial nerves IX, X, and XII. The Diagnoses section now contains more than 220 chapters and features an expanded congenital/genetic section to include craniosynostosis (Crouzon), CHARGE, mucopolysaccharidosis, and Down syndrome. Klippel-Feil syndrome is included in the Cervical Spine section.

You will also find many new graphics from our expert illustrators in both the print and electronic versions of this edition. Chapters have been meticulously updated with the addition of new references and images, including US and gross pathology images wherever appropriate.

Purchase of the book comes with an electronic version that allows for easy navigation between chapters and access to many more images as well as text that was excluded from the print version due to page constraints.

We trust that this third edition, like the prior editions, will appeal to both the beginning and experienced radiologist as well as the increasing number of general dental practitioners and specialists who are using CBCT technology in their offices. The book also serves as an excellent resource for the American Board of Oral and Maxillofacial Radiology examination, and we hope our medical colleagues will find it a valuable companion text to the fourth edition of *Diagnostic Imaging: Head and Neck*.

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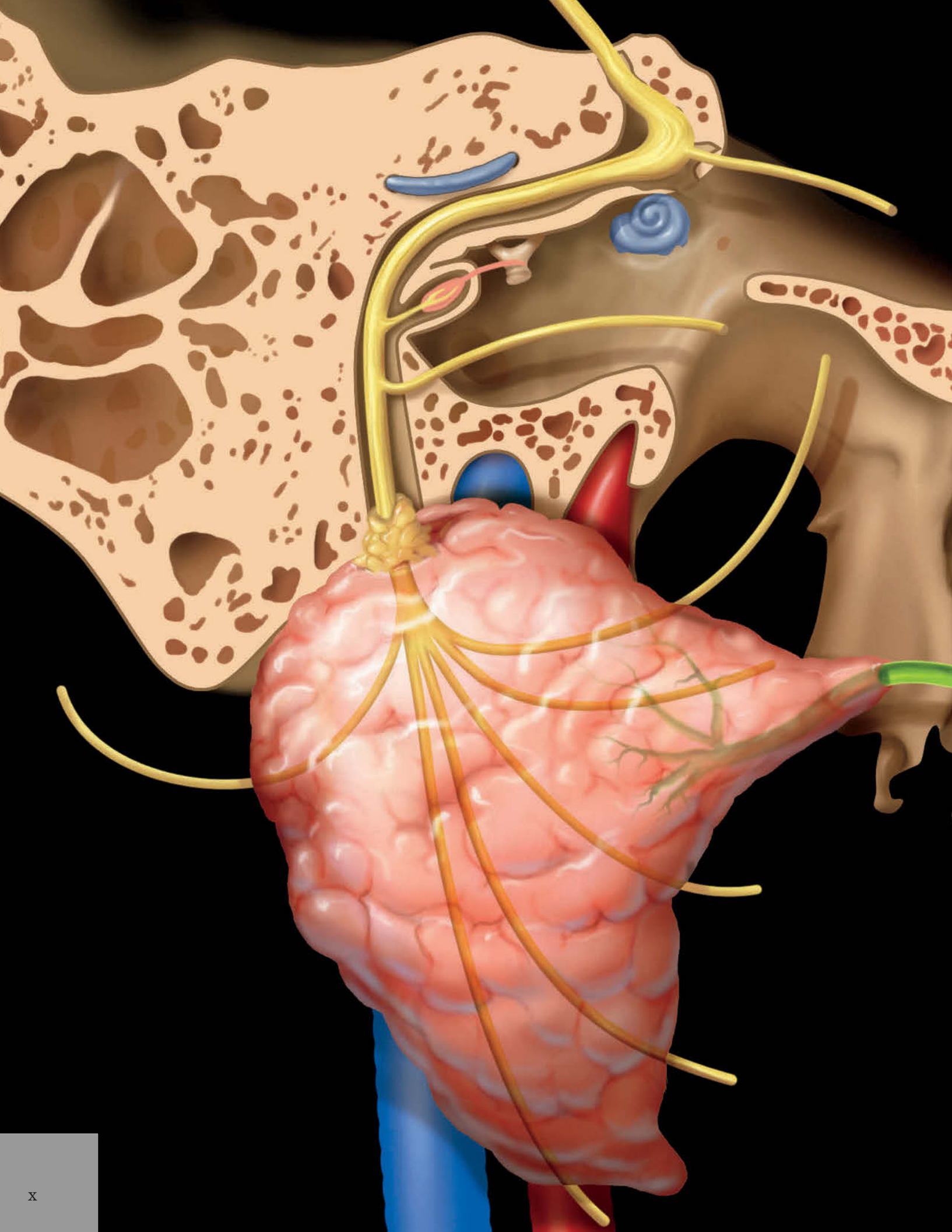

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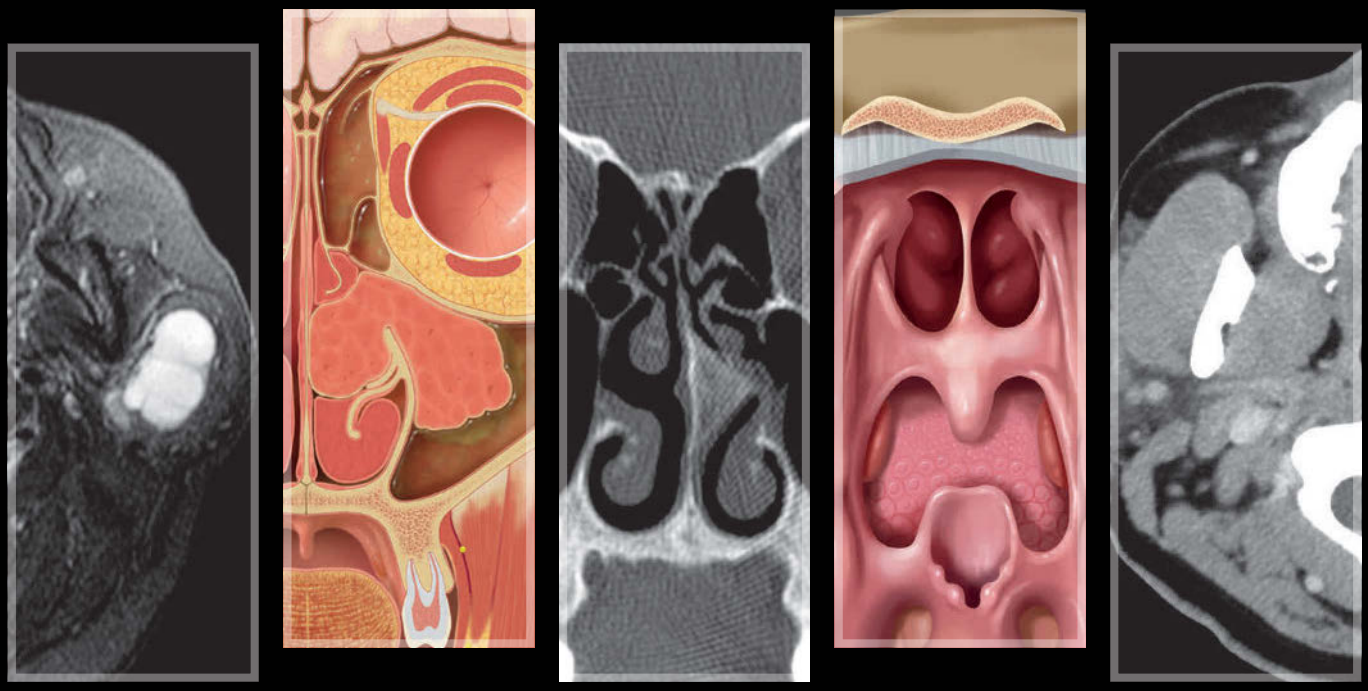

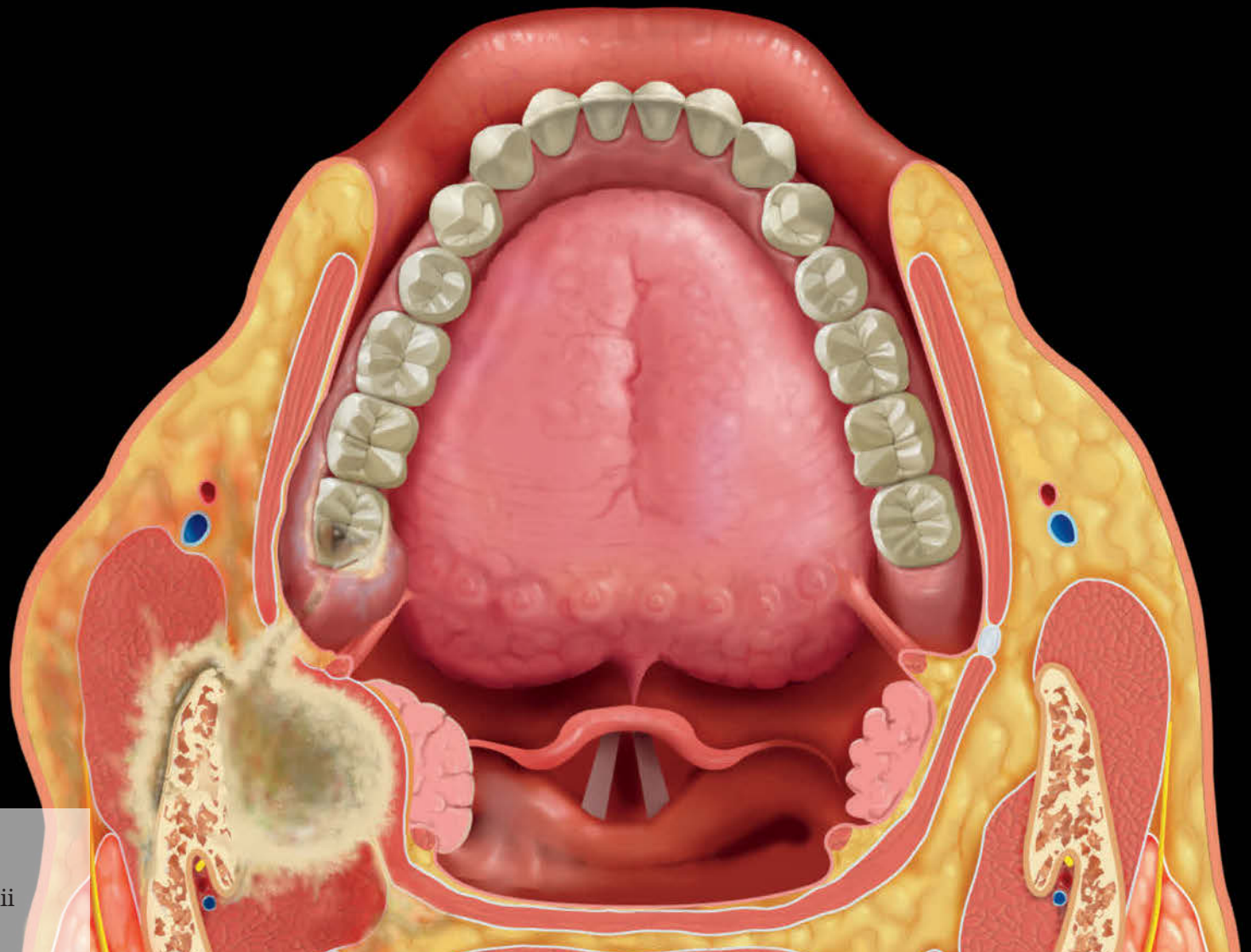

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THIRD EDITION

Koenig

Tamimi | Perschbacher | Demirturk

Diagnostic Imaging Oral and Maxillofacial

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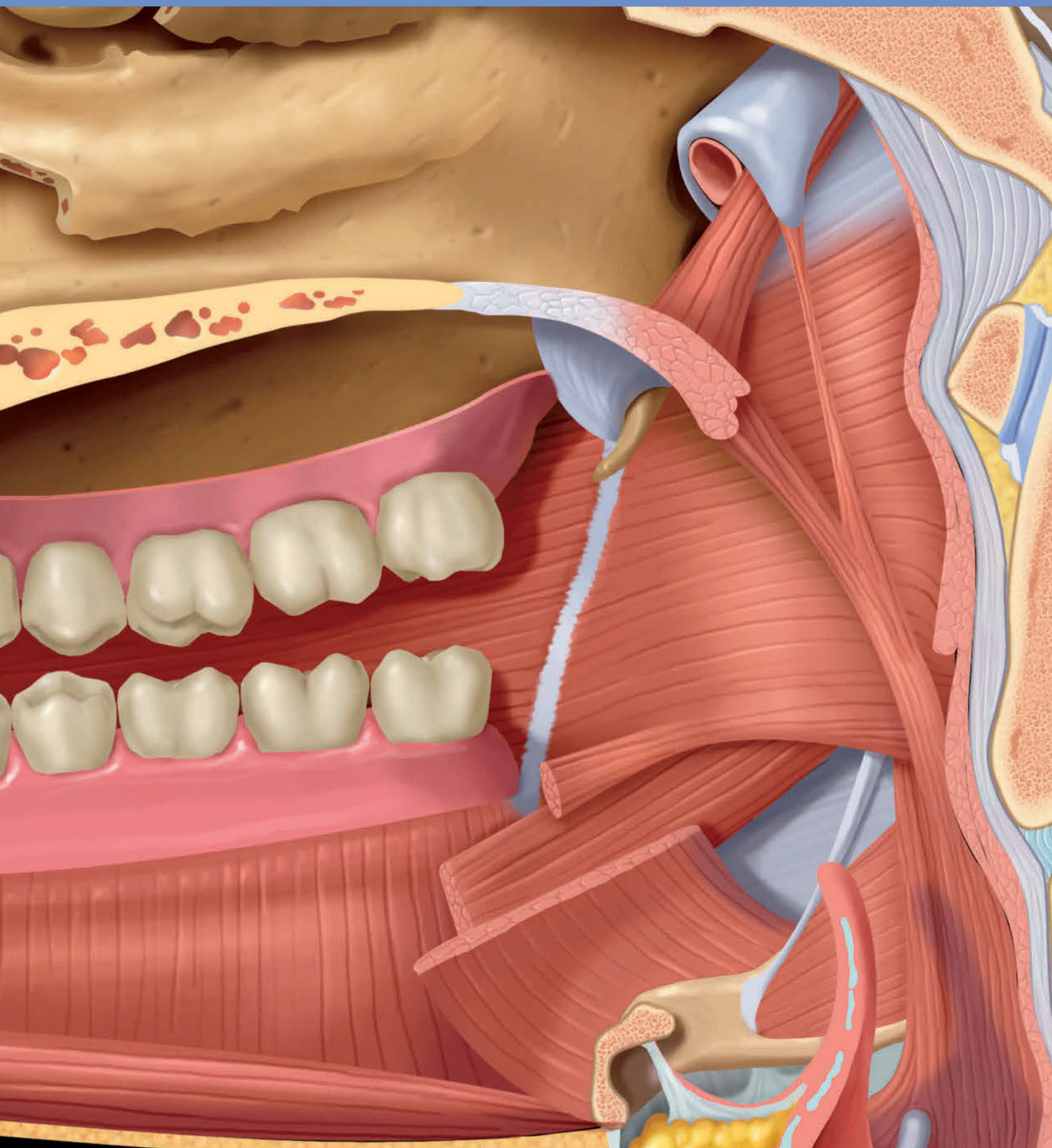

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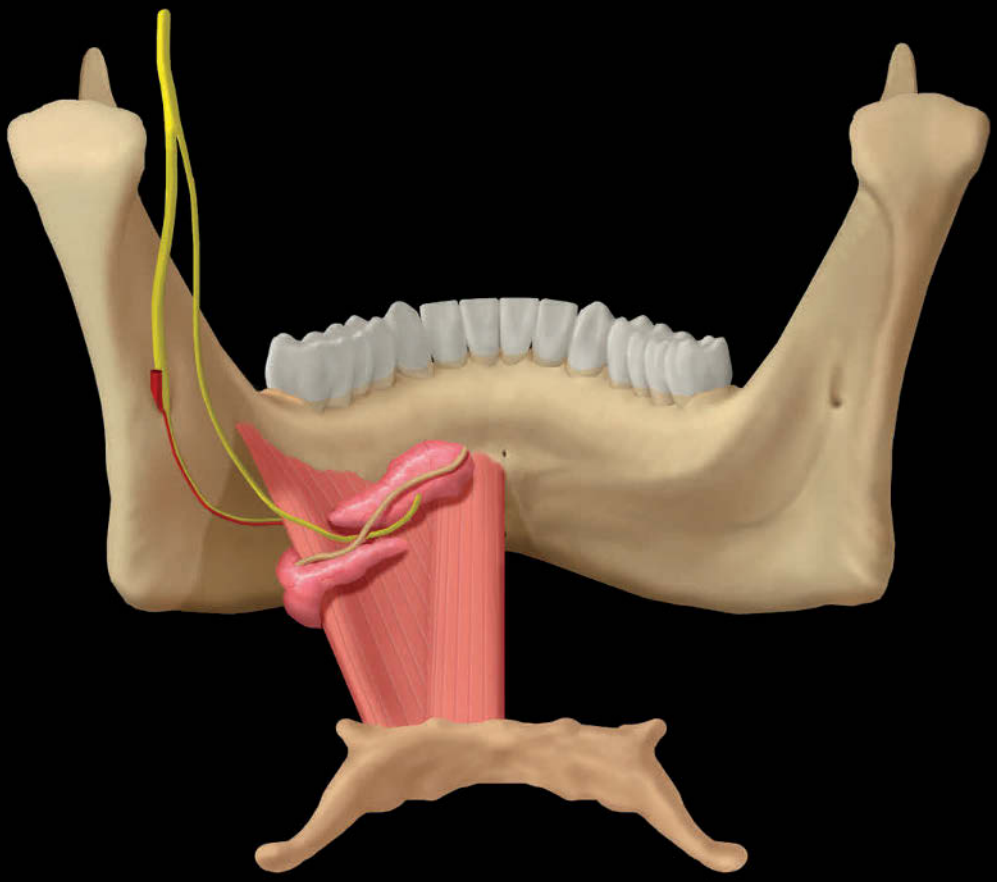


Teeth

TERMINOLOGY

Abbreviations

- Incisor (Inc), canine (C), premolar (PM), molar (M)

Synonyms

- C: Cuspid
- PM: Bicuspid

IMAGING ANATOMY

Overview

- Humans have 2 dentitions: **Primary** and **permanent**
- Teeth are divided into **maxillary** (upper) and **mandibular** (lower)
- Each jaw is divided into 2 quadrants: **Right** and **left**, separated by midline
- Each quadrant has **5 primary** and **8 permanent teeth**
  - **Primary**: 2 Incs (central and lateral), 1 C, 2 M (1st and 2nd)
  - **Permanent**: 2 Incs (central and lateral), 1 C, 2 PM (1st and 2nd), 3 M (1st, 2nd, and 3rd)
- Teeth can be **named** or **numbered**
- Naming teeth should follow this sequence: Dentition → jaw → side → tooth name
  - Example: **Primary maxillary right 1st M**; permanent mandibular left C
  - Exceptions are PMs and 3rd Ms: Only present in permanent dentition, so no need to use "permanent"
  - If only permanent teeth are present (all primary teeth have been exfoliated), no need to use "permanent"
- **Numbering teeth depends on country**
  - Most countries use **Fédération Dentaire Internationale (FDI) system for numbering**
    - **Quadrants are numbered**
    - Permanent: Upper right (UR) = 1, upper left (UL) = 2, lower left (LL) = 3, lower right (LR) = 4
    - Primary: UR = 5, UL = 6, LL = 7, LR = 8
    - **Teeth are numbered**
    - Permanent: Central Inc = 1, lateral Inc = 2, C = 3, 1st PM = 4, 2nd PM = 5, 1st M = 6, 2nd M = 7, 3rd M = 8
    - Primary: Central Inc = 1, lateral Inc = 2, C = 3, 1st M = 4, 2nd M = 5
    - Example: Permanent mandibular right 1st M = tooth #46 (**pronounced four-six**)
  - United States uses **universal system**
    - **Only teeth are numbered**
    - Permanent teeth start with #1 (maxillary right 3rd M) and go to #16 (maxillary left 3rd M; **pronounced sixteen**)
    - Mandibular left 3rd M is #17 (**pronounced seventeen**) and goes to mandibular right 3rd M #32 (**pronounced thirty-two**)
    - Primary teeth are labeled with letters A-T, starting with last M on UR: UR → UL → LL → LR
  - Other tooth numbering systems exist; check with local dental organization
  - When in doubt, **describe teeth by name**

Anatomy Relationships

- When describing teeth or objects in relation to teeth, **conventional anatomic positions** (inferior, superior, medial, lateral, anterior, posterior) **are not used**
- Position is described in relation to
  - **Midline of arch** (i.e., line between central Inc), **not anatomic midline**
    - All **surfaces** of teeth that are **in direction** of midline of arch are **mesial**
    - All **surfaces** of teeth **away** from midline of arch are **distal**
  - **Inside or outside of arch**
    - Surfaces toward face are **facial** (can use buccal if posterior, labial if anterior)
    - Surfaces toward tongue are **lingual** (can use palatal if maxillary)
  - **Anatomic tooth**
    - If **above crown** of tooth, use "**coronal to**"
    - If **below apices** of tooth, use "**apical to**"

Eruption Patterns

- 3 phases of eruption: Primary, mixed, and permanent dentitions
- **Primary dentition**
  - **Starts to erupt between 6-12 months**
  - 1st teeth are usually lower central Incs; last teeth are 2nd Ms
- **Mixed dentition**
  - **Combination of primary and permanent teeth** have erupted
  - 1st permanent teeth are permanent 1st Ms at 6 years
  - Exfoliation of primary Incs followed by eruption of permanent Incs (6-9 years)
  - Exfoliation of primary mandibular Cs followed by eruption of permanent mandibular Cs (9-10 years)
  - Exfoliation of primary Ms followed by eruption of PMs (10-12 years)
  - Exfoliation of primary maxillary Cs followed by eruption of permanent Cs (11-12 years)
    - **May get crowded out of arch**, either impacted or malerupted
    - **High incidence of dentigerous cyst formation** with impaction of these teeth
- **Permanent dentition**
  - **No more primary teeth in jaws**
  - Eruption of permanent 2nd Ms (11-13 years)
  - Eruption of 3rd Ms (17-21 years)
    - **Impactions are common**; **dentigerous cyst** may occur around crown of impacted tooth

Tooth Anatomy

- Teeth are made up of 4 basic anatomic structures: Enamel, dentin, cementum, and pulp
  - **Enamel**
    - Hardest substance in body = most mineralized (95% calcified) = highest radiographic density
    - Covers crown of tooth; contacts dentin at **dentinoenamel junction (DEJ)**
    - Contacts cementum at **cementoenamel junction (CEJ)**
    - Develops from ameloblasts

- **Dentin**
  - Makes up majority of tooth; provides resiliency to hard overlying enamel; 75% calcified
  - Contains dentinoblastic processes: Tooth becomes sensitive when dentin is exposed
- **Cementum**
  - Thin layer of calcified material covering root of tooth and providing attachment for periodontal ligament (PDL)
  - Not visible radiographically unless hypercementosis occurs
- **Pulp** (a.k.a. nerve)
  - Vital portion of tooth (tooth "dies" when pulp dies)
  - Contains nerves and vessels that enter and emerge through **apical foramen** of tooth
  - Most radiolucent portion of tooth
  - Crown portion called **pulp chamber** with pointy **pulp horns**; root portion called **pulp canal**

- Teeth are made up of **crown** and **root**
  - **Crown**: Everything above CEJ
    - Further subdivided into **occlusal/incisal, middle, and cervical 1/3**
    - Incs have incisal edges as functional component; all other teeth have cusps
  - **Root**: Everything below CEJ
    - Further subdivided into **cervical, middle, and apical 1/3**
    - Teeth can have single root or be multirooted; area between roots of tooth is called **furcation area**
    - Roots are named according to location in alveolar process: **Buccal, lingual, mesial, distal, mesiobuccal, distobuccal**

Periodontium

- Primary function is to support teeth; **when teeth are lost, periodontal bone recedes**
- Made up of **periodontal bone, PDLs, and gingiva**
  - **Periodontal bone**
    - Portion of alveolar processes of maxilla and mandible that come in direct contact with teeth
    - Most cervical aspect called **crest; corticated when healthy**
    - If **tooth is lost**, most cervical aspect of bone is called **residual ridge**
    - Bone at apex of tooth called **periapical bone**
    - Bone in furcation area called **furcal bone**
    - Thin radiopaque line seen radiographically lining tooth socket is called **lamina dura**
  - **PDL**
    - Multidirectional fibers that attach tooth to socket; offer resilience to tooth during function
    - Radiographically seen as uniform **radiolucent line on inside of lamina dura**
    - **If it loses uniformity, suspect pathology**
    - Houses **epithelial rests of Malassez**, which may contribute to formation of cyst lining for odontogenic cysts
    - Position in relation to tooth can determine if lesion is attached to tooth structure (inside PDL) or not (outside PDL)
  - **Gingiva** (a.k.a. gums)
    - Soft tissue component covering periodontal bone
    - Attaches to root to form small gingival sulcus with crown; **cannot be visualized radiographically**

ANATOMY IMAGING ISSUES

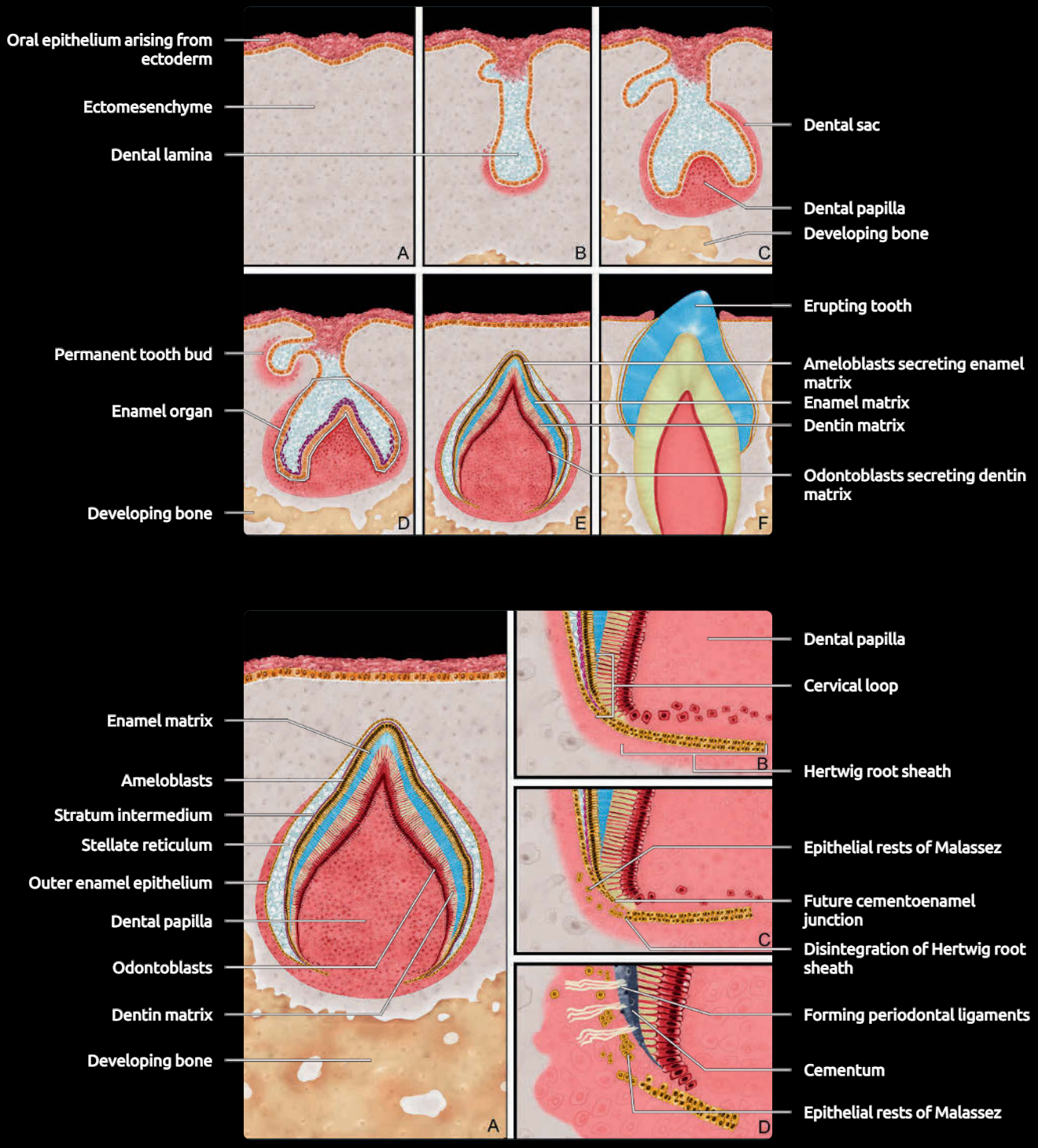
Imaging Recommendations

- For imaging of teeth for **caries, periapical or periodontal disease, intraoral radiography** is recommended
  - **Horizontal bitewings for caries** and early periodontal disease detection
  - **Vertical bitewings** for moderate to severe **periodontal disease**
  - **Periapical radiographs** if **periapical pathology** is suspected
  - **Pros**: High-resolution images showing fine changes in demineralization; low radiation dose, especially if F-speed film or digital radiography is used
  - **Cons**: Limited to dimensions of intraoral receptor; cannot see lesions or impacted teeth if they extend beyond
- **For general overview of teeth in jaws: Panoramic radiography**
  - Shows eruption pattern and impactions of teeth; presence of intraosseous pathology
  - **Pros**: Cost-effective; lower radiation dose when compared to CBCT
  - **Cons**: Distortion, magnification, and blurring can impede evaluation
- **For relationship of impacted teeth with vital anatomic structures: CBCT**
  - Can show inferior alveolar nerve (IAN) canals in relation to 3rd Ms if extraction is planned
  - Can show relationship of impacted Cs to anterior superior alveolar canal, nasopalatine canal, and floor of nasal cavity
  - **Pros**: 3D representation of 3D structures; 3D reformations can be obtained to give exact visualization of anatomy
  - **Cons**: Expensive imaging modality, generally not covered by insurance; higher radiation dose
  - If unable to obtain CBCT or CT, use intraoral radiography, **s**ame **l**ingual, **o**pposite **b**uccal (**SLOB**) **rule**, and **2 images at right angles** to one another
- If no radiographically visible signs of dental disease are noted in presence of dental pain
  - Consider referred pain from myogenic pain (e.g., myofascial pain trigger point) or neuropathic pain (e.g., trigeminal neuralgia)
  - If maxillary tooth pain, consider possible referring pain from adjacent nonodontogenic sinusitis

SELECTED REFERENCES

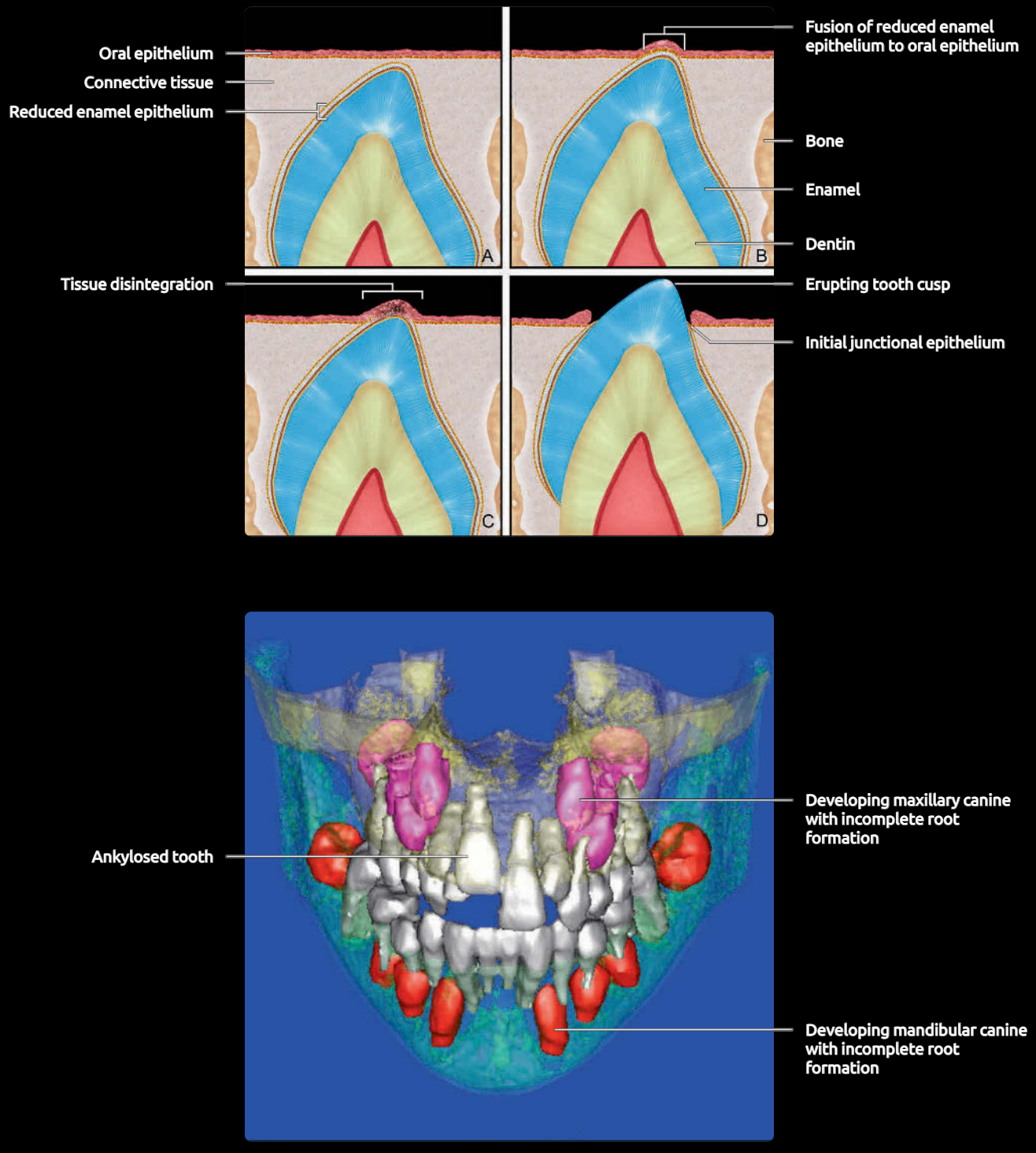
1. Yesiltepe S et al: Evaluation the relationship between the position and impaction level of the impacted maxillary third molar teeth and marginal bone loss, caries and resorption findings of the second molar teeth with CBCT scans. Oral Radiol. 38(2):269-77, 2022
2. Borohovitz CL et al: The diagnostic advantage of a CBCT-derived segmented STL rendition of the teeth and jaws using an AI algorithm. J Clin Orthod. 55(6):361-9, 2021
3. Nelson S et al: Wheeler's Dental Anatomy, Physiology and Occlusion. 11th ed. Elsevier, 2019
4. Riquieri N et al: Dental Anatomy and Morphology. 1st ed. Quintessence Publishing, 2019

ODONTOGENESIS



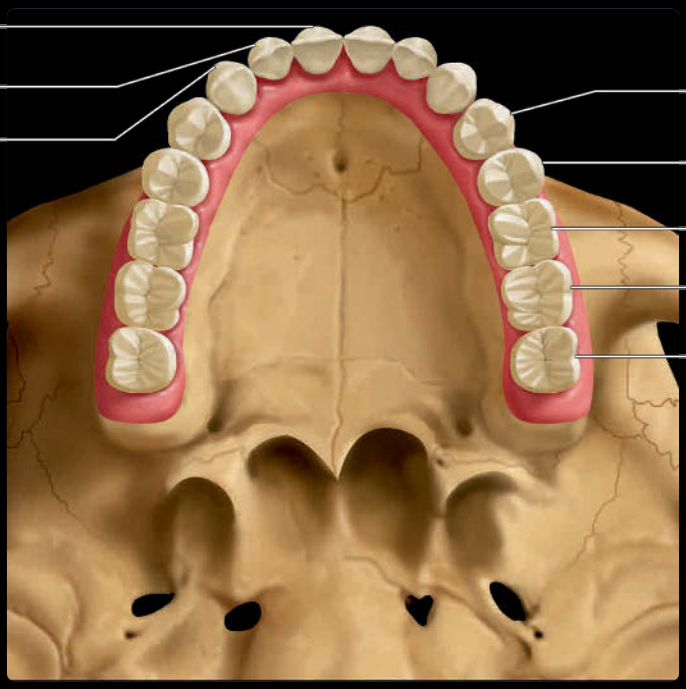
(Top) *Graphic shows stages of tooth development: (A) Initiation: Ectoderm develops oral epithelium and dental lamina, (B) bud stage: Dental lamina grows into bud penetrating the ectomesenchyme, (C) cap stage: Enamel organ forms cap surrounding dental papilla and surrounded by dental sac, (D) bell stage: Differentiation of enamel organ and dental papilla into different cells types, (E) apposition stage: Secretion of dental tissue matrix, and (F) maturation: Full mineralization of dental tissues.* **(Bottom)** *Graphic shows stages of root development: (A) Apposition stage, (B) enamel deposition completion at the cervical loop and formation of Hertwig epithelial root sheath from inner and outer enamel epithelium cells, (C) root sheath disintegration and fragmentation of some of its cells into epithelial rests of Malassez, and (D) formation of cementum and periodontal ligaments with persistence of these epithelial remnants, which may be the source of the epithelial component of some odontogenic cysts and tumors.*

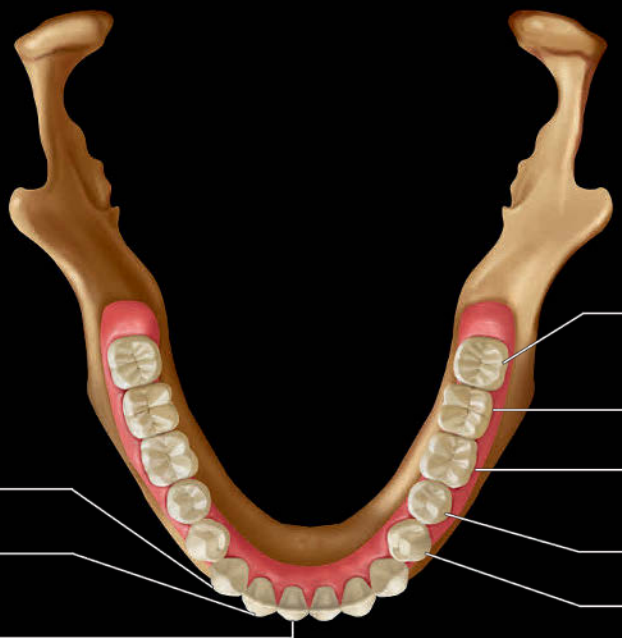
TOOTH ERUPTION AND IMPACTION



(Top) *Graphic shows the process of tooth eruption: (A) Enamel organ reduces to thin layers covering enamel and secretes enzymes, (B) fusion of the reduced enamel epithelium with the oral epithelium, (C) disintegration of the central fused tissues, leaving a canal for tooth movement, and (D) peripheral fused tissues peel back from the crown as the tooth erupts and form initial junctional epithelium that migrate cervically to cementoenamel junction.* **(Bottom)** *The age of the patient can be determined by examining the eruption of the teeth. This CBCT 3D reformation shows that the permanent incisors and 1st molars have erupted, but the premolars have not. This puts the patient's age between 8-10 years. 3D reformations can be helpful in evaluation of erupting teeth if malocclusion and malalignment are present. Note that the maxillary right central incisor has not fully erupted, although the apical foramen is almost closed. This may be due to ankylosis (loss of periodontal ligament) of the tooth. (Courtesy 3D Diagnostix, Inc.)*

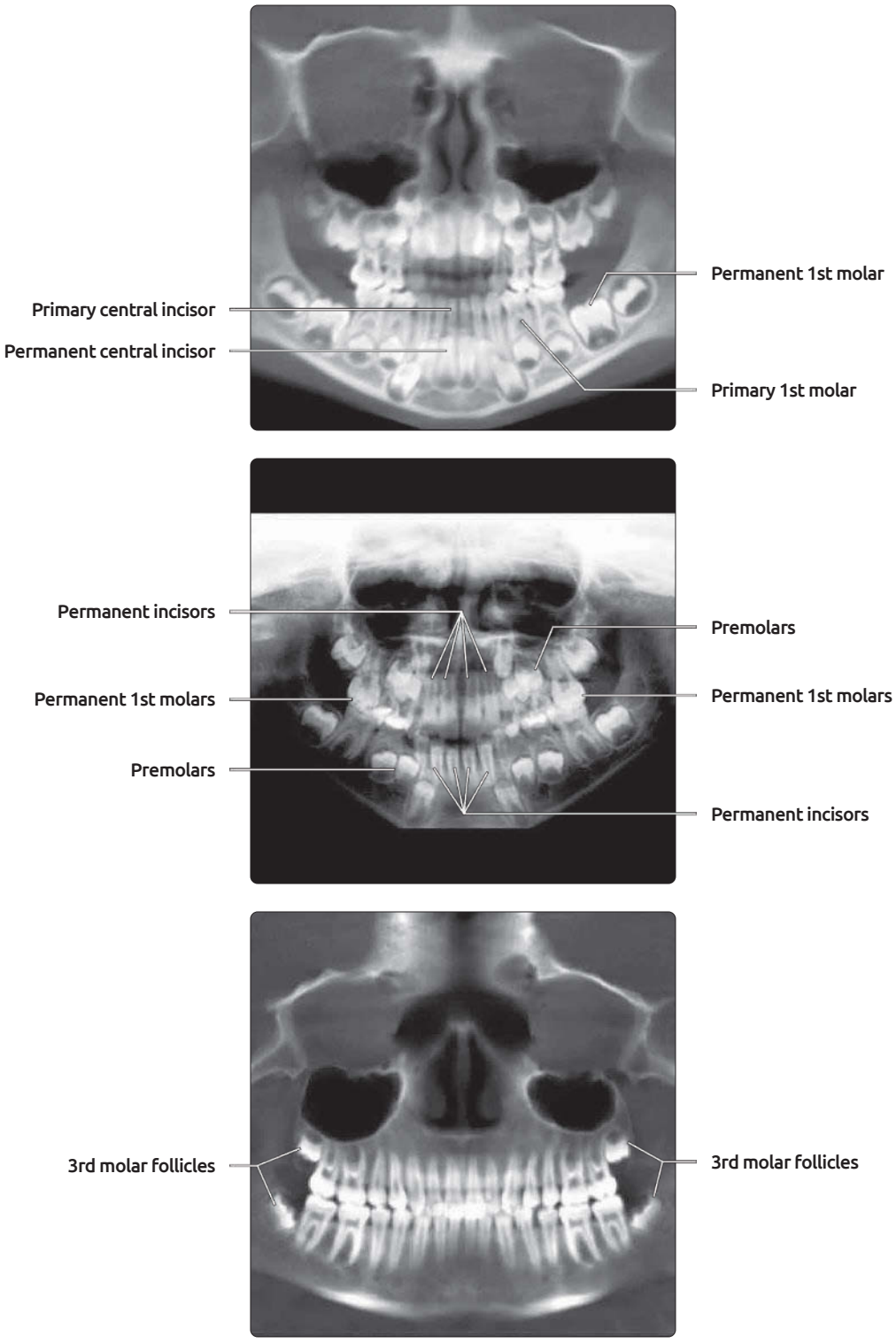
TOOTH DEVELOPMENT





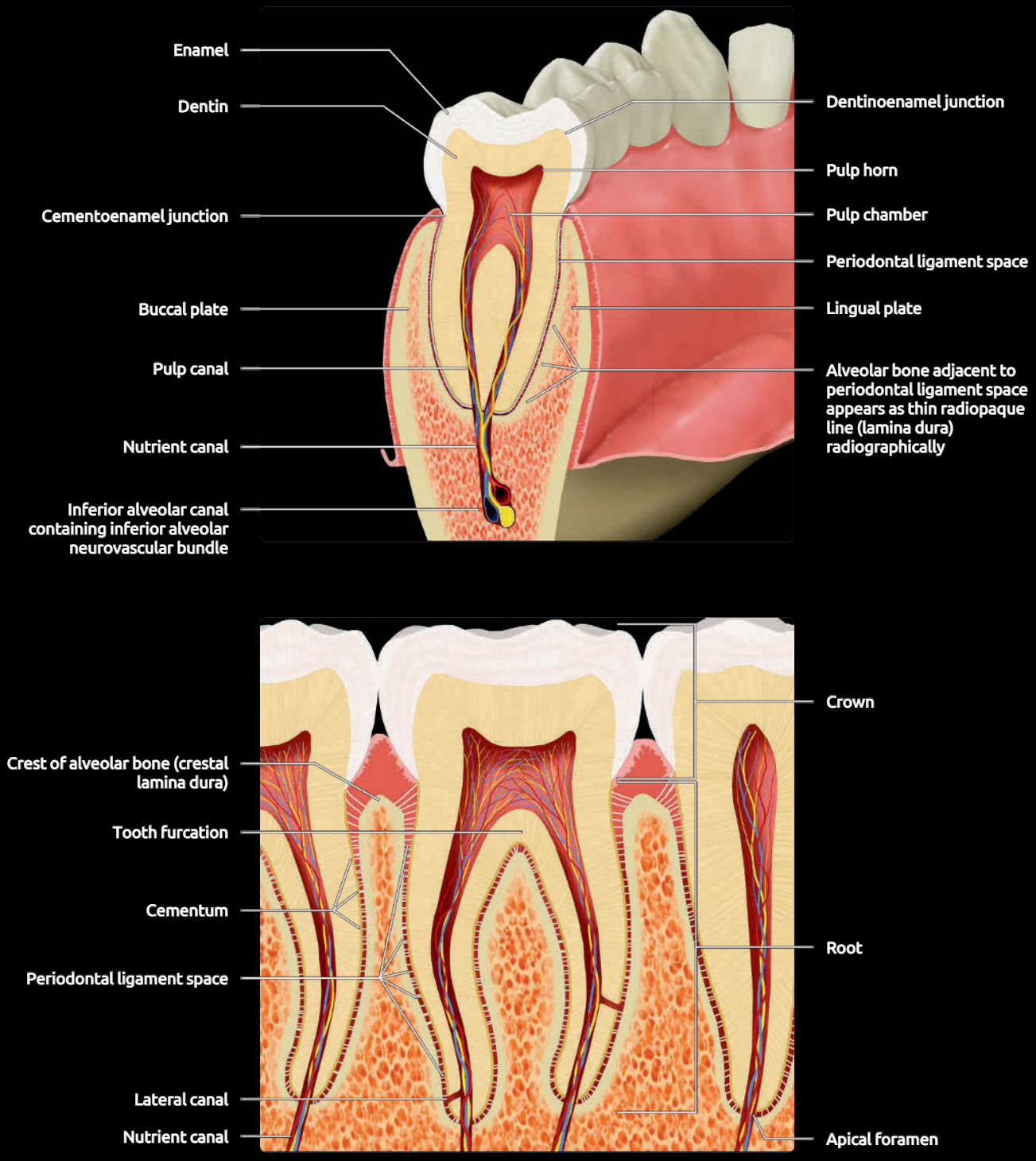
(Top) *The maxilla has 16 permanent teeth arranged in 2 quadrants: The upper right (UR) quadrant, a.k.a. quadrant 1, and the upper left (UL) quadrant, a.k.a. quadrant 2. Eruption ages are in parentheses. The functional cusps on the maxillary posterior teeth are lingual (palatal) cusps.* **(Bottom)** *The mandible has 16 permanent teeth arranged in 2 quadrants: The lower left (LL) quadrant, a.k.a. quadrant 3, and the lower right (LR) quadrant, a.k.a. quadrant 4. Eruption ages are noted in parentheses. The functional cusps on the mandibular posterior teeth are the buccal (facial) cusps. The permanent maxillary and mandibular incisors and canines have similarly named deciduous predecessors. The predecessors of the 1st and 2nd premolar teeth are the 1st and 2nd deciduous molars, respectively. The deciduous incisors and canines have a single root, the mandibular deciduous molars have 2 roots, and the maxillary deciduous molars have 3 roots.*

TOOTH ERUPTION



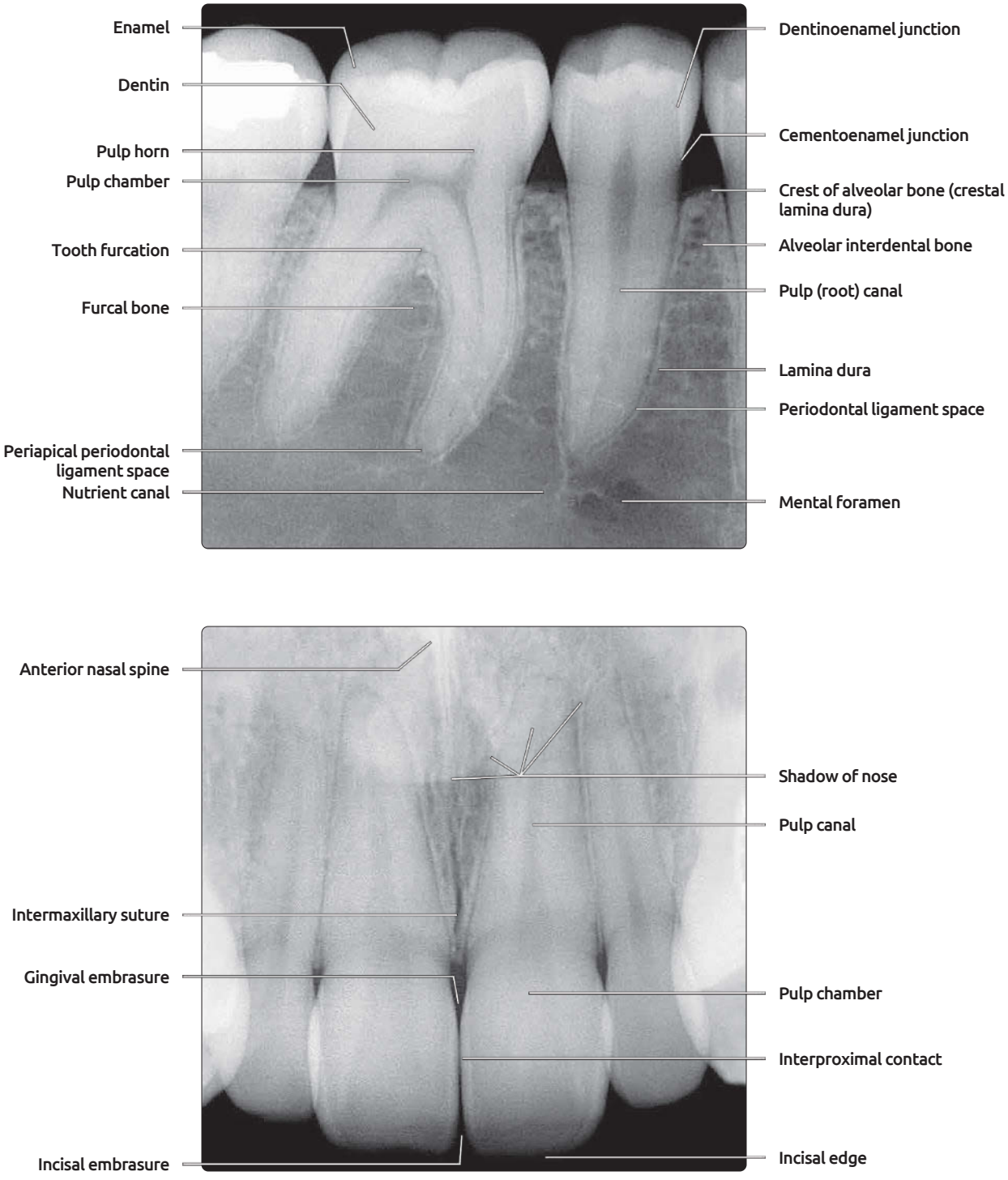
(Top) *Panoramic CBCT reformat shows a patient at the primary dentition stage. All 20 primary teeth have erupted into the oral cavity and are in occlusion, but all permanent teeth are still unerupted. Examination of the follicles of the permanent teeth for any displacement or expansion is recommended when evaluating images for the primary dentition phase. It is also important to note any missing permanent teeth to aid in future orthodontic treatment planning.* **(Middle)** *Panoramic radiograph shows a patient at the mixed dentition stage. The upper and lower permanent 1st molars as well as the upper and lower incisors have erupted. The premolars have not erupted yet, indicating that the patient is between 8 and 10 years of age.* **(Bottom)** *Panoramic CBCT reformat shows a patient in the permanent dentition stage. All erupted teeth are permanent. The developing 3rd molars are present but unerupted. The stage of 3rd molar development indicates that the patient is between 17 and 20 years of age.*

TEETH NOMENCLATURE AND ERUPTION AGES



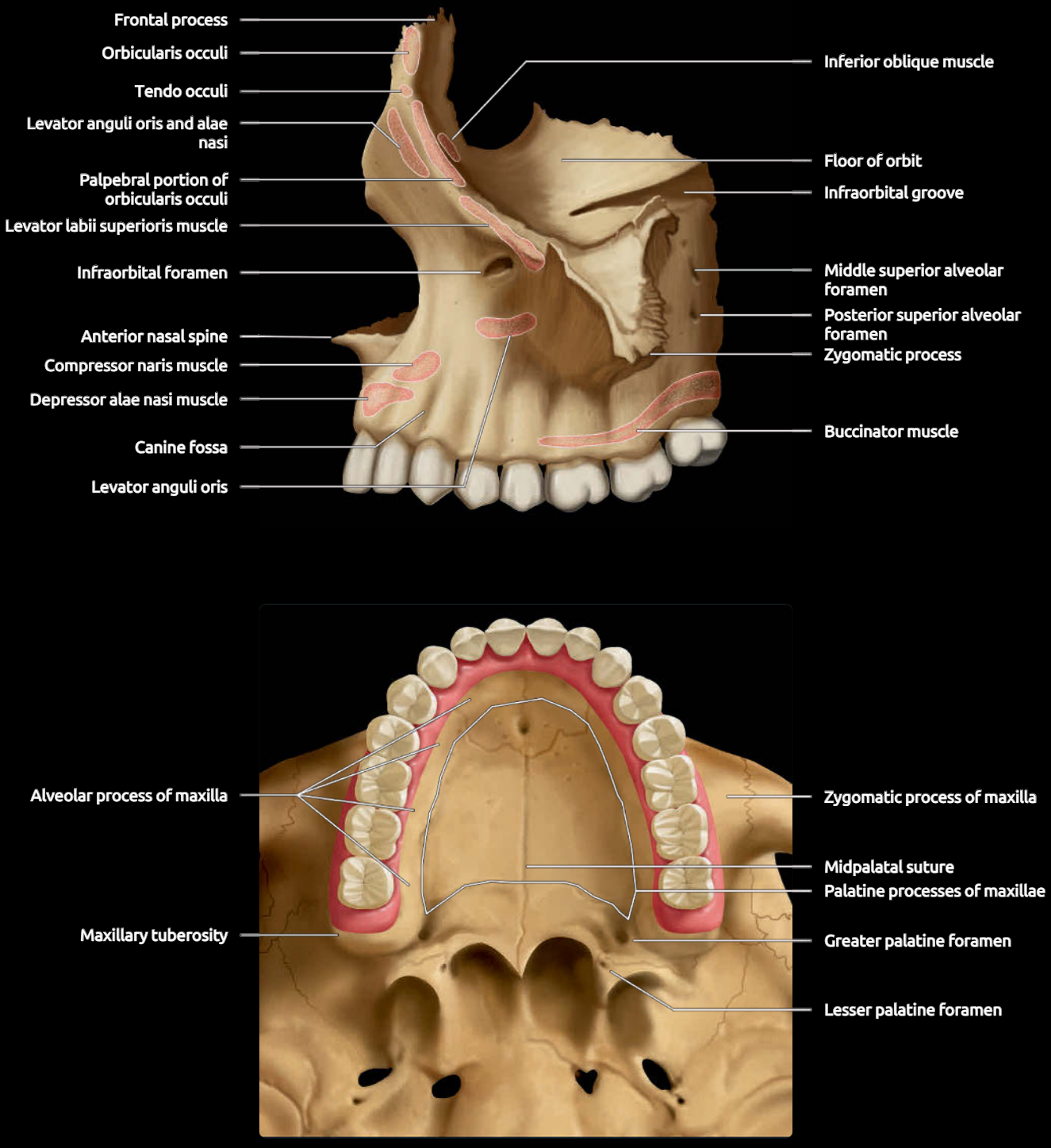
(Top) *Graphic shows a mandibular 1st molar in the cross section through the mesial root. Identification of the location of pathology in relation to the dentinoenamel junction (DEJ) and cementoenamel junction (CEJ) helps in classifying caries and periodontal disease. Cross sections of the teeth are the most common reformation for dental applications, such as implant and impaction analysis, as they allow for evaluation of alveolar bone width and height and accurate localization of the inferior alveolar nerve (IAN) canal.* **(Bottom)** *Graphic shows a sagittal cross section of a mandibular 1st molar. The tooth is attached to the socket through the periodontal ligaments (PDLs). The crest of the healthy alveolar bone is located ~ 1-2 mm apical to the CEJ of a tooth. Innervation and vasculature exit through the apical foramen, but, on occasion, lateral canals may exit through the lateral aspects of the root. If pulpal death occurs, bacteria can seep through the lateral canals, causing lateral radicular inflammation, and through the apical foramina, causing periapical inflammation.*

DENTAL ANATOMY



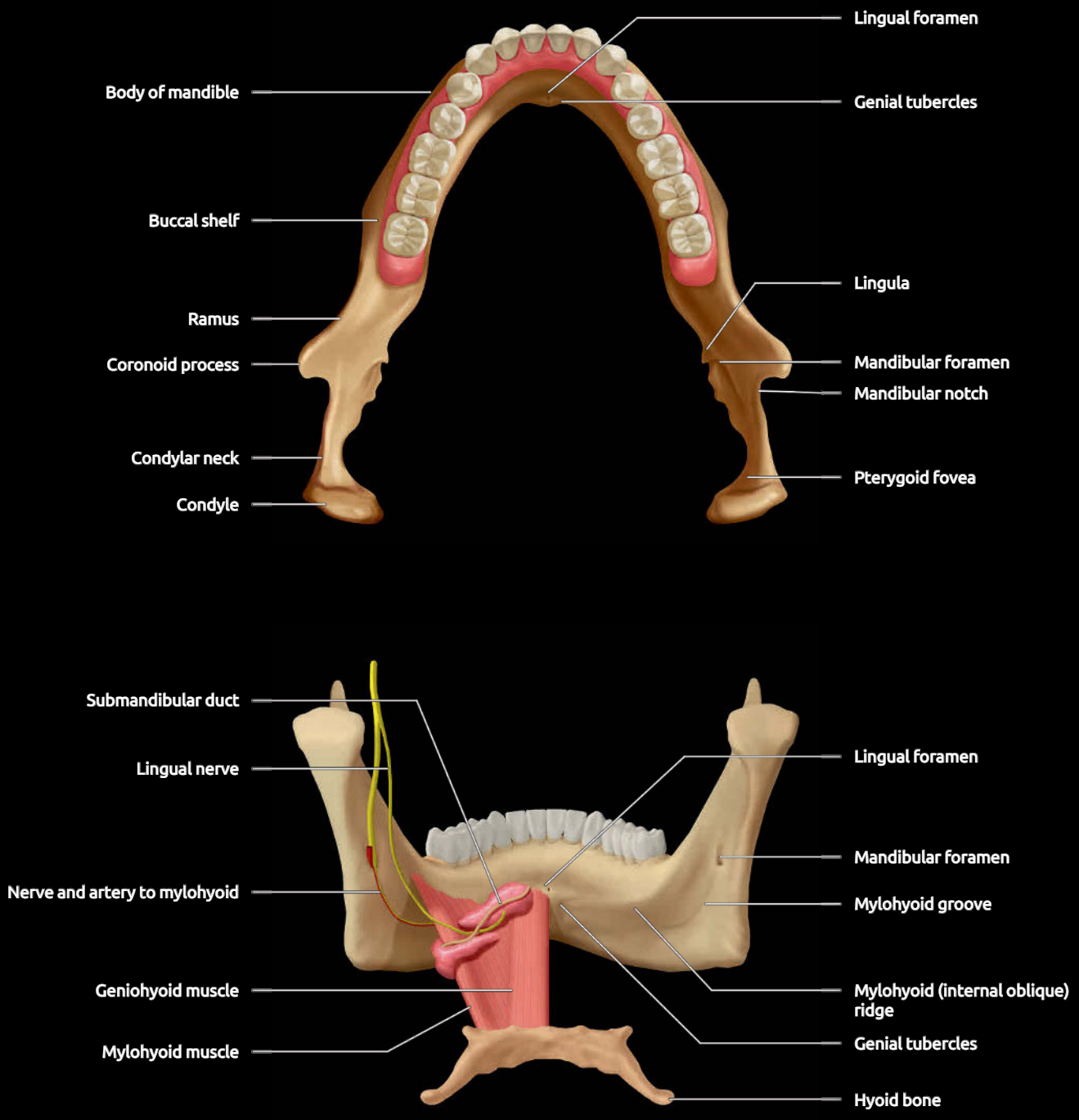
(Top) *Periapical radiograph shows normal dental and periodontal anatomy. The PDL space is a thin radiolucent line that surrounds the root of the tooth. The lamina dura is a thin radiopaque line that surrounds the tooth socket radiographically. Healthy alveolar bone crests (crestal laminae dura) are corticated. Nutrient canals may appear as small corticated canals within the bone connected to the apical foramen. (Courtesy M. Kroona, DXT.)* **(Bottom)** *Periapical radiograph of the central incisors shows the normal anatomic landmarks in this area. It is important to realize that soft and hard tissue superimpositions may occur when imaging teeth, and their recognition is necessary to determine normal from abnormal. Evaluation of the interproximal contact point and crown contours is important, as caries tends to occur cervical to the contact point, and incomplete contact or improper crown contour may lead to plaque accumulation, resulting in caries and periodontal disease. (Courtesy M. Kroona, DXT.)*

GRAPHICS



(Top) *Graphic shows the lateral aspect of a disarticulated maxilla with muscle origins and insertions outlined. CNV2 enters through the posterior aspect of the orbital floor, courses anteriorly in a groove or fully formed infraorbital canal, and exits anteriorly through the infraorbital foramen. The zygomatic process of the maxilla is a thick portion of bone that is usually avoided during LeFort 1 osteotomies or Caldwell-Luc procedures.* **(Bottom)** *Graphic of hard palate and maxillary alveolar ridge viewed from below shows the palatine processes of the maxillary bone. The premaxilla is an embryonic process and does not form a separate bone in adult humans. The 2 palatine processes meet in the midline in the maxillary midline suture (midpalatal suture, intermaxillary suture, or median suture). The horizontal plate of the palatine bone completes the hard palate posteriorly. Note the incisive foramen in the anterior midline and the greater and lesser palatine foramina at the junction of the maxilla and the palatine bones and in the palatine bone, respectively.*

GRAPHICS



(Top) *Axial graphic of the mandible seen from above demonstrates the condyle and condylar neck leading to the more inferior ramus. The mandibular foramen is seen on the inner surface of the mandibular ramus. The superiorly projecting coronoid processes attach the temporalis muscle tendons. The lateral pterygoid muscle (superior belly and most of the inferior belly) inserts in the pterygoid fovea. The lingula is a lip-like projection at the anteroinferior aspect of the mandibular foramen.* **(Bottom)** *Graphic shows the posterior view of the mandible. The nerve to the mylohyoid muscle branches off V3 before it enters the mandibular canal and creates a slight impression in the bone called the mylohyoid groove. The mylohyoid muscle attaches to the mylohyoid ridge, and the geniohyoid muscle attaches to the genial tubercles. The lingual foramen exits superior to the genial tubercles in the midline.*

Mandible Fracture

KEY FACTS

IMAGING

- Best diagnostic clue: Discontinuity in mandibular osseous structure
- Panoramic radiograph best initial evaluation, followed by CBCT (max 0.4 mm voxel) or thin-slice axial bone CT with coronal & 3D reformat
- CBCT/bone CT appearance
  - Radiolucent, noncorticated lines with variable diastasis, angulation, & comminution
  - Condylar fracture (fx): **Condylar head pulled medially & inferiorly** by lateral pterygoid muscle ("unfavorable fx")
- Intraoral periapical or CBCT if alveolar or dental fx suspected
- Mandible simulates bony "ring": **2 breaks** common (50%)
  - Parasymphyseal fx often associated with contralateral angle/body or subcondylar fx
  - Bilateral subcondylar fxs after direct impact to symphysis

TOP DIFFERENTIAL DIAGNOSES

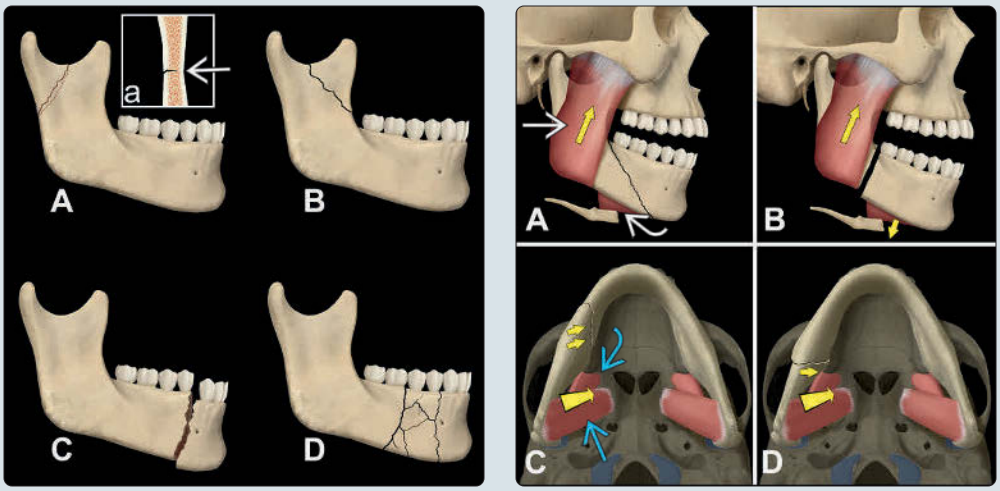
- Pseudo-fxs
  - Nutrient canal
  - Inferior alveolar nerve canal/accessory canals
  - Mental foramen
  - Palatoglossal airway space on panoramic images

PATHOLOGY

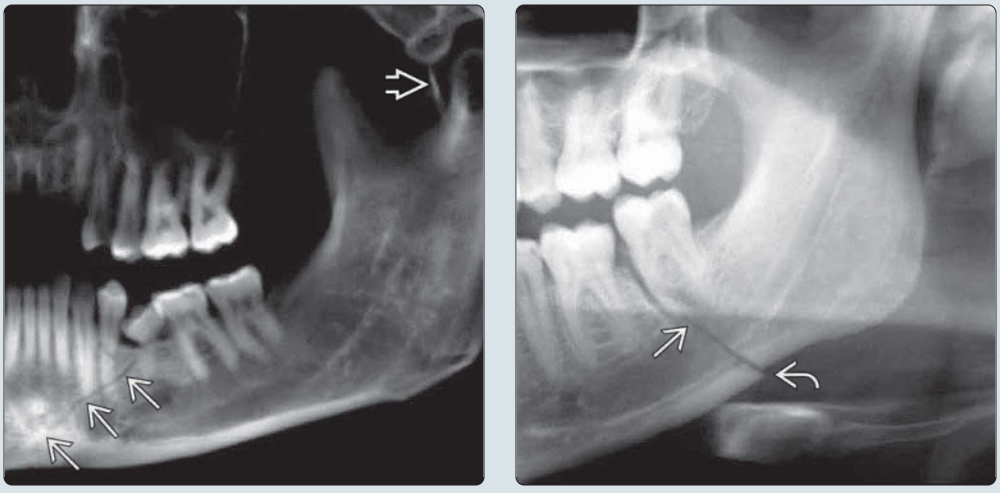
- Causes of mandibular fx: Motor vehicle crashes (40%), assault (40%), fall (10%), sports (5%)
- 15% have ≥ 1 other facial bone fx

CLINICAL ISSUES

- Presentation: Jaw pain, abnormal mobility, malocclusion
- Mandibular fx frequencies
  - Condylar process (36%), body (21%), angle (20%), symphyseal/parasymphyseal (15%), ramus (3%), alveolar (3%), coronoid process (2%)
- **Look for 2nd fx**, TMJ dislocation (empty fossa), or facial fx

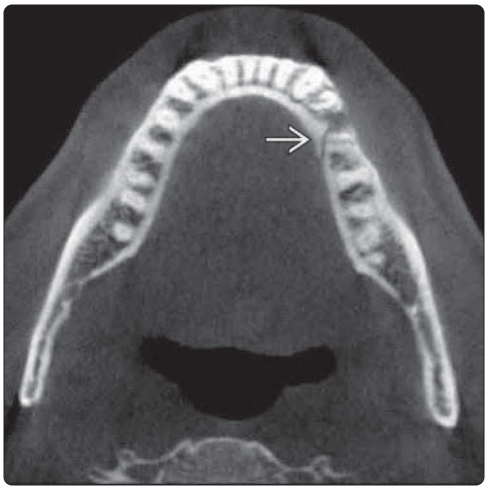


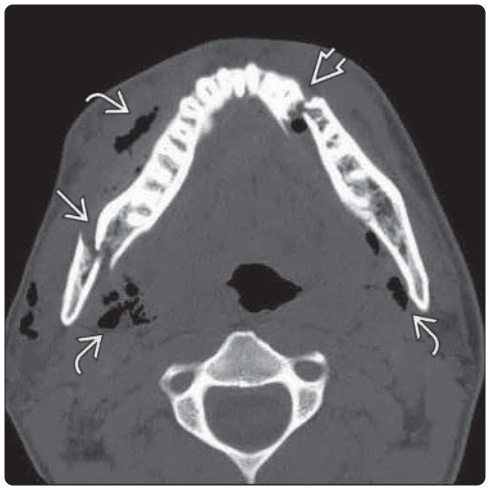
(Left) *Graphic shows types of fractures: (A) Greenstick (incomplete), mostly children, where one cortex bends (inset a.), (B) simple closed (no oral cavity communication), (C) compound open (intra- or extraoral communication; most common), & (D) comminuted.* **(Right)** *Graphics show favorable (A & C) & unfavorable (B & D) fractures. Masseter and mylohyoid muscles stabilize segments (A) & displace segments (B). Medial & lateral pterygoid muscles stabilize segments (C) & displace segments (D).*



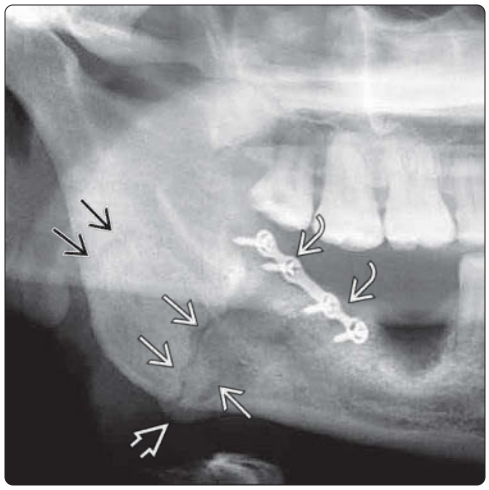
(Left) *Panoramic reformat CBCT shows a favorable, nondisplaced oblique fracture of the left anterior mandible. The condyle sustained an oblique sagittal fracture (not shown), but the displaced medial segment is partially visualized. (Courtesy M. Noujeim, DDS.)* **(Right)** *Panoramic radiograph shows an unfavorable compound fracture through the mandibular body. Note the separation sign & the step sign from displacement caused by pull of the masseter & mylohyoid muscles.*

(Left) *Axial CBCT shows a nondisplaced oblique parasymphyseal fracture of the left mandible. (Courtesy M. Noujeim, DDS.)* **(Right)** *Axial bone CT shows displaced mandibular fractures of the right angle & left parasymphysis. A fracture through the teeth is considered open & requires antibiotics. Contralateral fractures are commonly present as the mandible is essentially a fixed ring of bone. Extensive lacerations caused the associated soft tissue emphysema.*

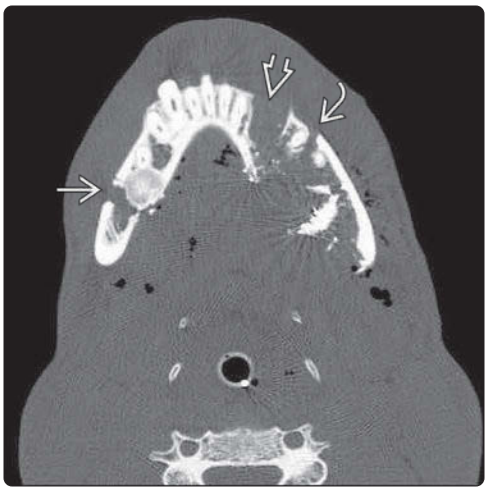


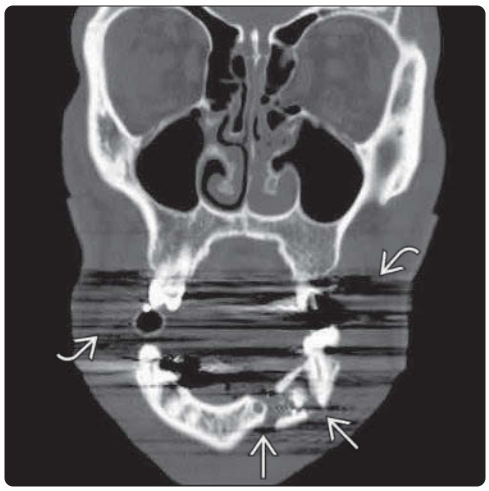


(Left) *Axial bone CT shows a displaced fracture through the anterior ramus. The mandibular canal appears disrupted, suggesting possible clinical paresthesia. Air inclusions are noted in the adjacent soft tissue.* **(Right)** *Panoramic radiograph shows a compound fracture through the right mandibular angle. A surgical plate with multiple screws was used to reduce the fracture. A bony callus, indicative of healing, is seen at the inferior cortex. Note the palatoglossal airway space simulating a fracture through the ramus.*



(Left) *Axial bone CT shows extensive comminuted fractures of the mandible sustained from a gunshot injury. The main fracture lines involve the right mandibular body & left parasymphyseal regions, but the left mandible is significantly traumatized. The left canine tooth is missing.* **(Right)** *Coronal bone CT of comminuted fractures in the same patient shows left parasymphyseal fractures. Note axial artifact from metallic bullet fragments & dental restorations.*





Segmental Odontomaxillary Dysplasia

KEY FACTS

TERMINOLOGY

- Developmental abnormality of bone of unknown etiology, unilaterally affecting maxilla, teeth, and associated gingiva
- Synonym: Hemimaxillofacial dysplasia

IMAGING

- Localized, unilateral enlargement of maxilla with teeth abnormalities and vertically oriented trabeculae
- Increased density of maxillary alveolar bone with vertically oriented coarse trabeculae; bone may appear as ground glass
- Teeth may be missing (frequently premolars) or have abnormal or delayed root development
- Thin, vertical radiolucencies may represent nutrient canals

TOP DIFFERENTIAL DIAGNOSES

- Fibrous dysplasia
- Regional odontodysplasia
- Segmental hemifacial hyperplasia
- Gingival fibromatosis

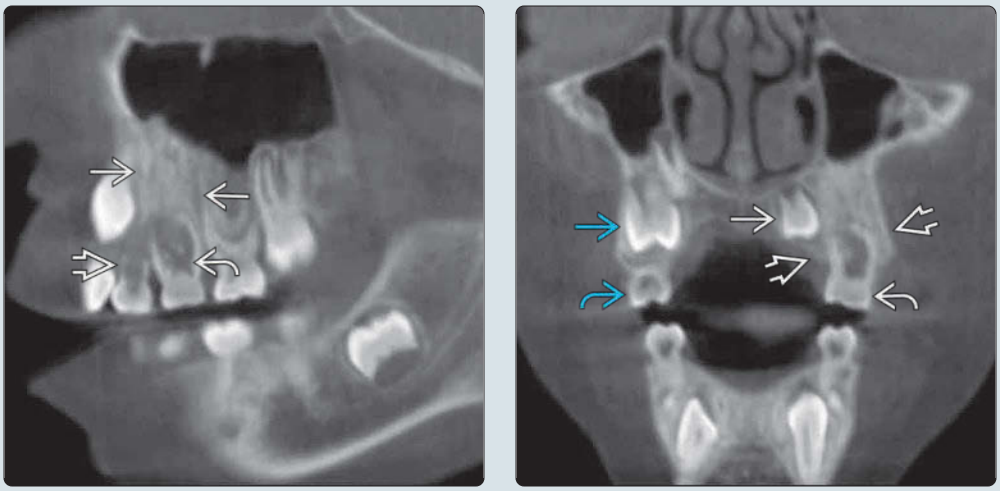
CLINICAL ISSUES

- Asymptomatic, unilateral enlargement of maxilla with absent premolars and retained deciduous teeth
- Facial cutaneous lesions: Becker nevus, hypo- and hyperpigmentation
- Facial hypertrichosis, facial asymmetry
- 5-27 years of age; usually diagnosed in 1st decade
- M > F; some report M = F
- Removal of nonrestorable teeth; orthodontic treatment &/or prosthetic recontouring of teeth to restore form and function
- Nonprogressive; prognosis excellent

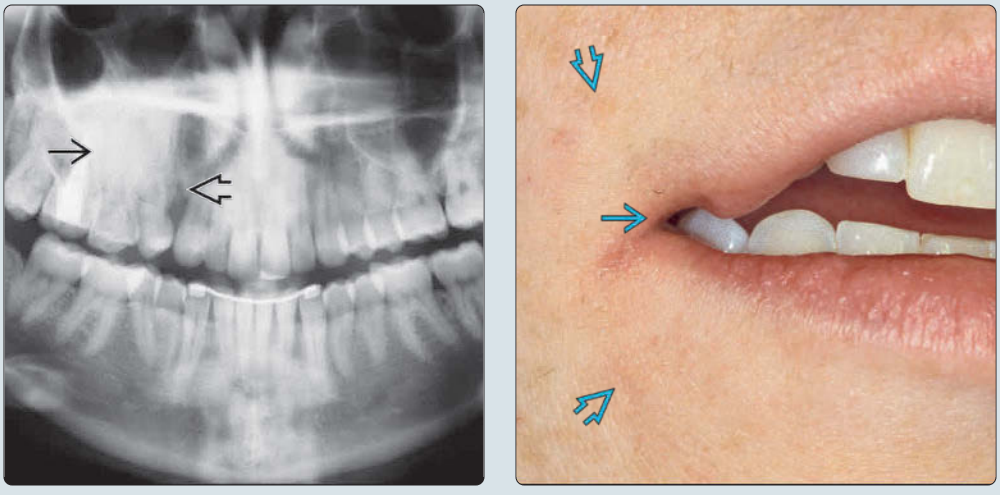
DIAGNOSTIC CHECKLIST

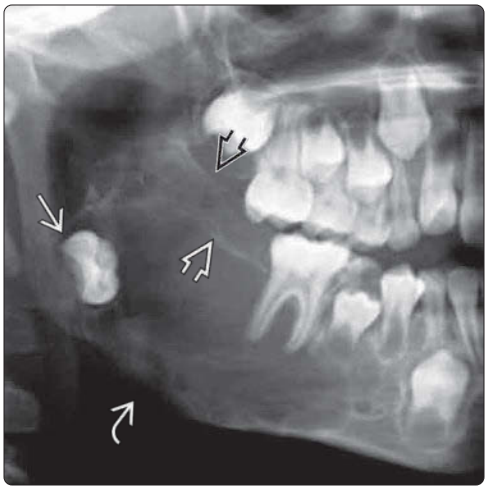
- Consider: Definitive treatment should be delayed until end of somatic growth

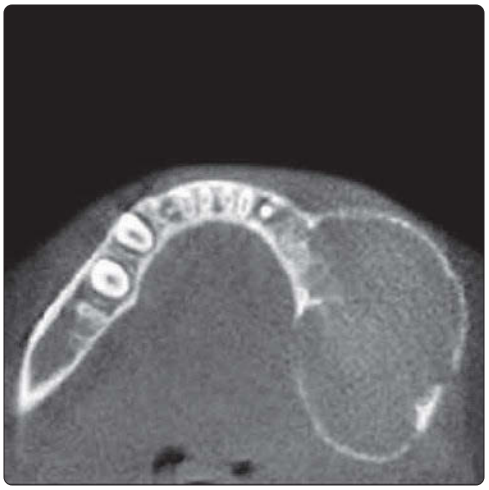
(Left) *Sagittal CBCT reformat in an 8-year-old girl shows ↑ density of the left maxilla with linear radiolucencies, possibly representing nutrient canals, and abnormal resorption of the deciduous canine and 1st molar. Features are consistent with segmental odontomaxillary dysplasia (SOD).* **(Right)** *Coronal CBCT in same patient shows ↑ width of left maxilla. Developing 1st premolar is displaced palatally and is smaller than right. The 2nd premolar was missing. The left 1st deciduous molar is larger than the right.*



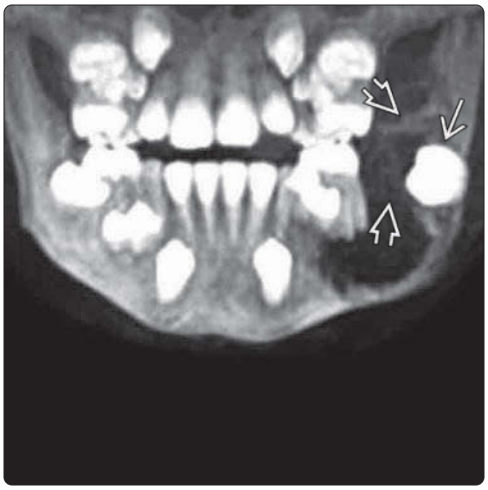
(Left) *Cropped panoramic radiograph in a 26-year-old woman shows increased density of the alveolar bone in the right maxillary premolar area. There is a radiolucency between the deciduous 1st molar and the canine suggestive of a cleft. Clefting has been reported in other cases. Both premolar teeth are missing.* **(Right)** *Photograph of the same patient shows commissural lip clefting and facial hyperpigmentation, which are frequently associated with SOD. Hypertrichosis was also present.*

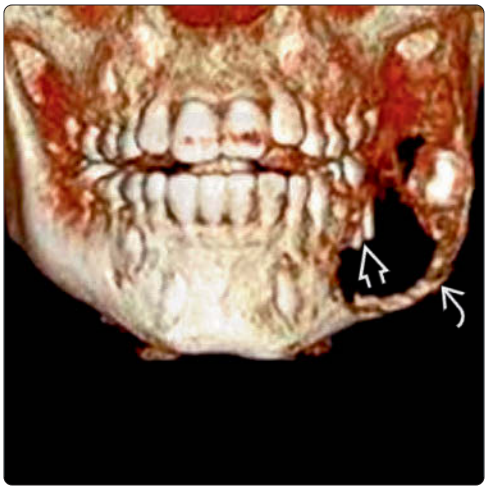






(Left) *Panoramic radiograph shows a large AF in the right posterior mandible. The lesion is pericoronal to the developing crown of the 2nd permanent molar, which has been displaced inferiorly and posteriorly by the lesion. Note expansion of the inferior border of the mandible and the anterior border of the ramus. A faint septum is evident. (Courtesy M. Noujeim, DDS.)* **(Right)** *Axial CBCT shows a large, expansile, unilocular AF in the left posterior mandible. (Courtesy M. Noujeim, DDS.)*

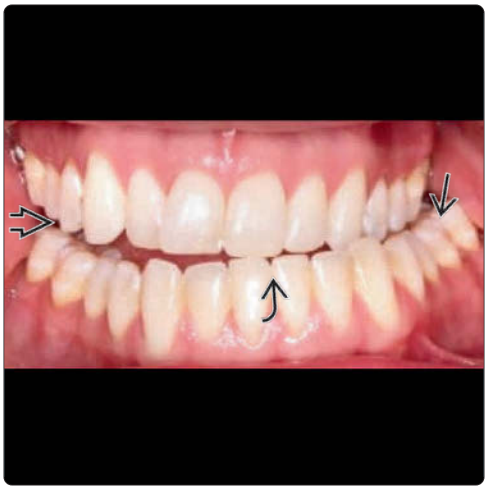


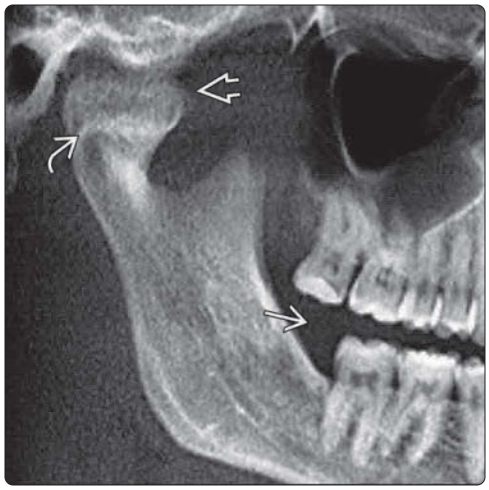


(Left) *Panoramic reformat CBCT shows a large AF in the left posterior mandible associated with the crown of the unerupted developing 2nd permanent molar. The lesion has expanded into the anterior border of the ramus, and septa are evident. (Courtesy M. Noujeim, DDS.)* **(Right)** *CBCT 3D reconstruction in the same patient shows expansion and the mandibular left 1st permanent molar roots visible within the lesion. The inferior border of the mandible is spared. (Courtesy M. Noujeim, DDS.)*

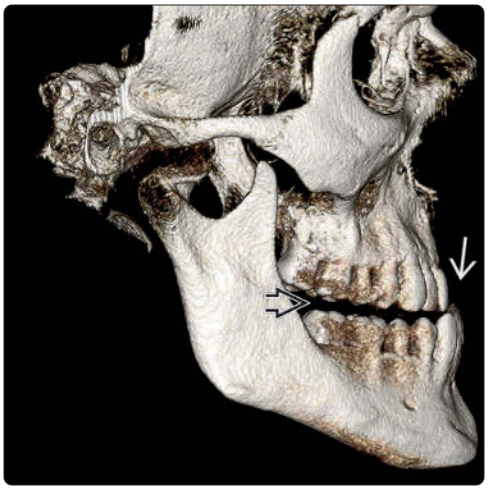
(Left) *CBCT 3D reconstruction in the same patient shows the AF viewed from below. Note the buccal expansion and the roots of the 1st molar clearly visible. (Courtesy M. Noujeim, DDS.)* **(Right)** *Axial CBCT in the same patient shows cortex is expanded and thinned but not perforated. Note how the lesion curves back on itself to form an acute angle with the normal cortex. This is characteristic of a tumor rather than a cyst, which causes hydraulic expansion and produces more obtuse angles. (Courtesy M. Noujeim, DDS.)*

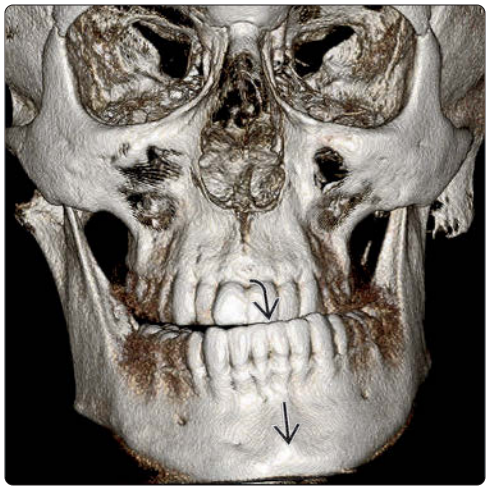
(Left) *Clinical photograph shows dentition in maximum intercuspation. There is an acquired right posterior open bite, left posterior crossbite, and shift of the mandibular dental midline to the left.* **(Right)** *Panoramic reformatted CBCT in the same patient shows an osteochondroma extending from the superior surface of the native condyle. The mass is displacing the mandible and altering the occlusion. (Courtesy D. Way, DDS.)*



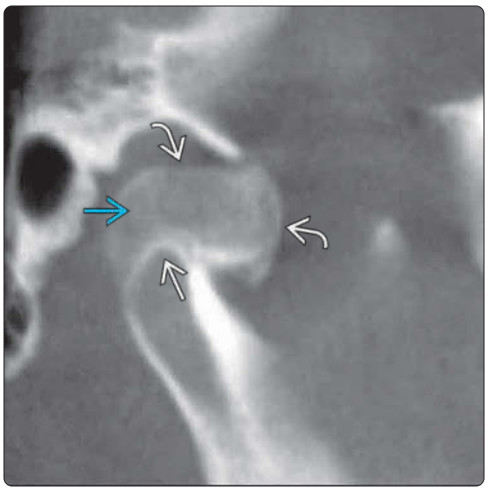


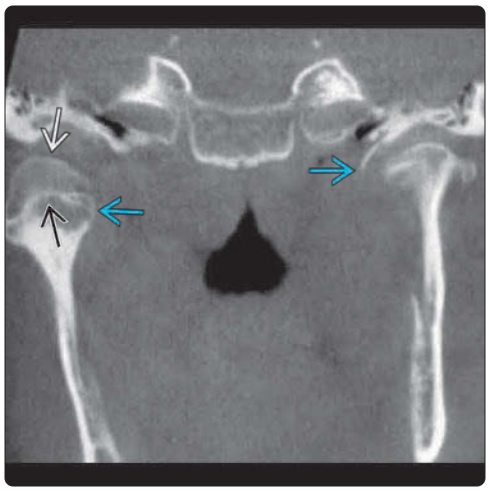
(Left) *CBCT surface rendering in the same patient shows a right posterior open bite and negative anterior overjet.* **(Right)** *CBCT surface rendering in the same patient shows mandibular displacement. The osseous and dental midlines of the mandible shift to the left.*





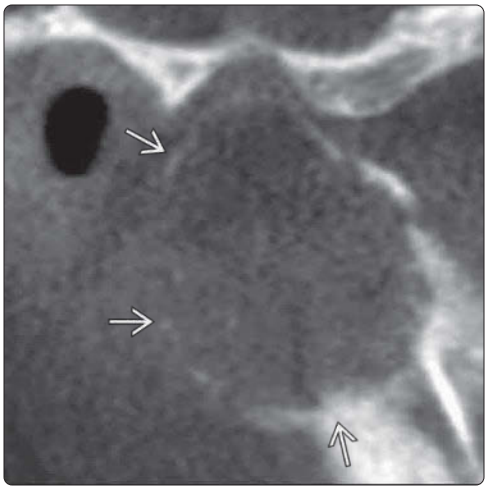
(Left) *Sagittal oblique CBCT in the same patient distinctly shows the intact native condyle. The margins of osteochondroma are smooth and well defined. Medullary bone is observed internally.* **(Right)** *Coronal CBCT in the same patient shows the mediolateral extent of the osteochondroma as it extends superiorly from native condyle. Note the difference in axial levels between the 2 condyles due to the inferior displacement of the right condyle by the tumor.*

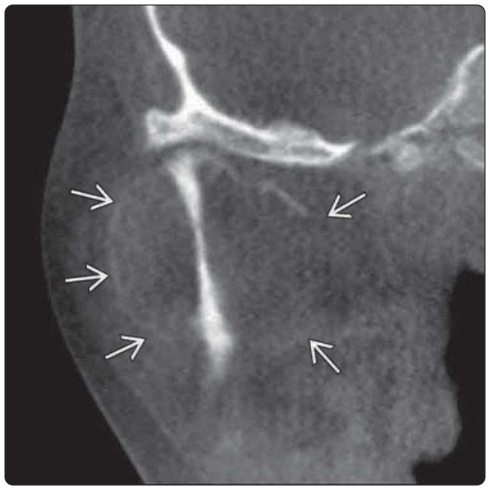




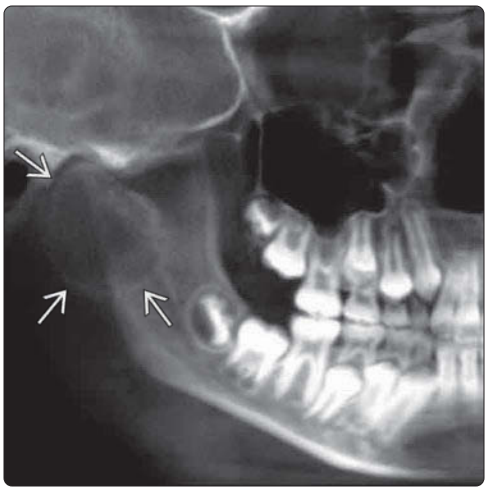
(Left) *Clinical photograph shows an 8-year-old girl with a rapidly enlarging, nonpainful right facial swelling resulting from a giant cell lesion containing focal areas of an ABC.* **(Right)** *Volume-rendered CBCT in the same patient shows facial swelling.*

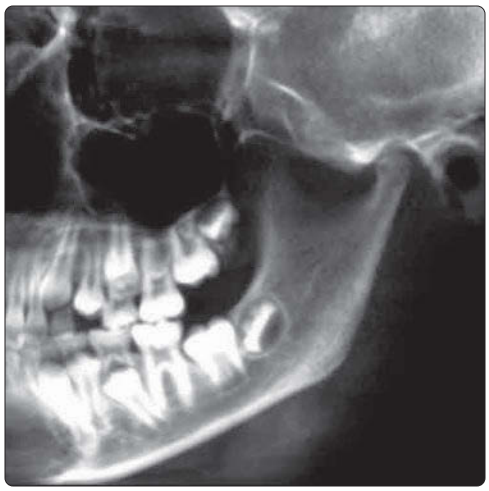
(Left) *Sagittal oblique CBCT of the right TMJ shows an expansile lytic lesion with its epicenter within the condyle. The lesion margins are relatively well defined and mostly corticated. The condyle is not displaced.* **(Right)** *Coronal CBCT section of the right TMJ in the same patient shows medial and lateral expansion. The lateral surface of the lesion shows a thin cortex exhibiting hydraulic-type expansion.*





(Left) *CBCT panoramic reconstruction of the right side in the same patient shows the enlarged condyle and superior ramus with hydraulic-like corticated expansion. The teeth are in maximum interdigitation, indicating no displacement of the condyle/mandible.* **(Right)** *CBCT panoramic reconstruction of the left 1/2 of the mandible in the same patient shows that occlusion and condyle/fossa spatial relationships are maintained.*





DIFFERENTIAL DIAGNOSIS

Common

- Hyperdontia: Isolated Teeth

Less Common

- Hyperdontia: Associated With Cleft Palate
- Down Syndrome

Rare but Important

- Cleidocranial Dysplasia
- Gardner Syndrome (Familial Adenomatous Polyposis)
- Ehlers-Danlos Syndrome

ESSENTIAL INFORMATION

Key Differential Diagnosis Issues

- Isolated supernumerary teeth very common
- Multiple supernumerary teeth may indicate accompanying systemic or inherited disorder

Helpful Clues for Common Diagnoses

- **Hyperdontia: Isolated Teeth**
  - Key facts
    - Mesiodens > distodens > premolars, canines, laterals
    - **Mesiodens** often seen palatal to maxillary incisors
    - **Distodens** (distomolar, paramolar) seen distal to, lingual to, or buccal to 3rd molars
    - Extra premolars, canines, laterals seen in either jaw
    - May be erupted or unerupted (potential for development of dentigerous cysts)
  - Imaging
    - Often microdonts and conical crowns
    - Surrounding follicular space present if unerupted

Helpful Clues for Less Common Diagnoses

- **Hyperdontia: Associated With Cleft Palate**
  - Key facts
    - Teeth usually missing in area of cleft
    - Supernumerary teeth sometimes seen in other areas
  - Imaging
    - May be normal or malformed, erupted or unerupted
- **Down Syndrome**
  - Key facts
    - Underdeveloped midfacial region, altered tongue size
    - Delayed eruption, class III malocclusion
  - Imaging
    - Supernumerary teeth or hypodontia, microdontia

Helpful Clues for Rare Diagnoses

- **Cleidocranial Dysplasia**
  - Key facts
    - Absent or hypoplastic clavicles with skeletal anomalies
    - Multiple supernumerary teeth, often unerupted
    - Retained primary teeth
    - Delayed eruption of permanent teeth
  - Imaging
    - Multiple unerupted teeth
    - Open skull sutures and wormian bones
    - Dense and coarse trabecular pattern
- **Gardner Syndrome (Familial Adenomatous Polyposis)**
  - Key facts
    - Familial colorectal polyposis and epidermoid cysts
    - Multiple osteomas
  - Imaging
    - Multiple supernumerary teeth
- **Ehlers-Danlos Syndrome**
  - Key facts
    - Joint hypermobility, connective tissue fragility
    - Hyperextensible skin, atrophic scars, and bruising
  - Imaging
    - Multiple supernumerary teeth or hypodontia
    - Pulp calcification, malformed or short roots
    - Odontogenic keratocysts
    - Early-onset periodontitis, premature loss of 1° teeth

SELECTED REFERENCES

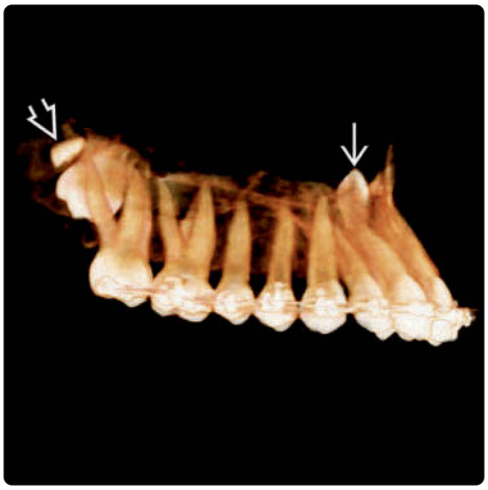
1. Bogdanowicz A et al: Tooth migration in a female patient with hyperdontia: 11-year follow-up case report. J Clin Med. 12(9):3206, 2023
2. Tofts LJ et al: Pediatric joint hypermobility: a diagnostic framework and narrative review. Orphanet J Rare Dis. 18(1):104, 2023

Hyperdontia: Isolated Teeth

Hyperdontia: Isolated Teeth

(Left) *Axial reformat 3D CBCT shows 2 mesiodens ➡ palatal to the maxillary incisors, both oriented to the posterior. When 1 mesiodens is noted, a check for a 2nd one should be made.* **(Right)** *Clinical photograph shows a mesiodens ⇨ in the anterior maxilla that has erupted between the central incisors. Note the unusual clinical crown morphology. Mesiodens is the most common supernumerary tooth and may be single or paired. Erupted supernumerary teeth may present an orthodontic challenge.*

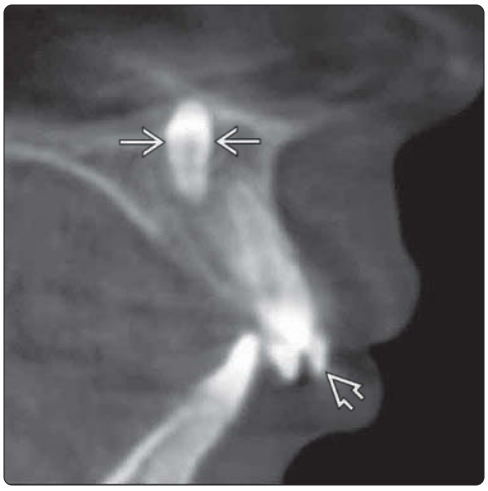
Hyperdontia: Isolated Teeth



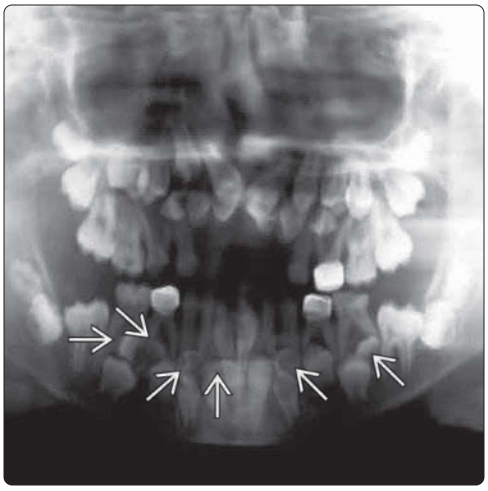
Hyperdontia: Isolated Teeth

(Left) *Sagittal reformat 3D CBCT of a 14-year-old girl shows an inverted mesiodens ➡ with the crown protruding into the nasal fossa. The patient was imaged to plan for surgical extraction of the mesiodens. Note the developing 4th molar (distodens) ➡, which was not visible on panoramic view and was found incidentally.* **(Right)** *Axial CBCT exhibits 3 supernumerary mandibular premolars ➡ located to the lingual side of the roots of the erupted permanent premolars ⇨. This is the 3rd most likely site for supernumerary teeth.*

Hyperdontia: Associated With Cleft Palate



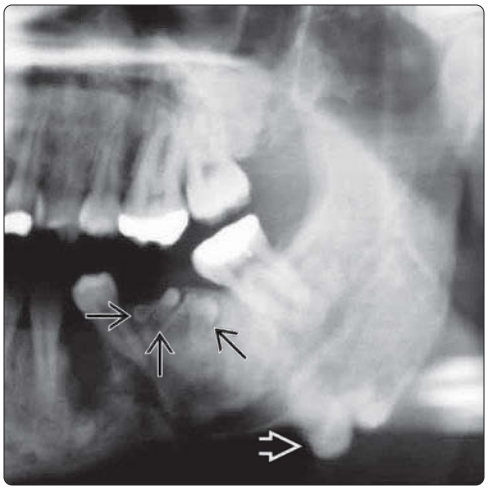
Cleidocranial Dysplasia



(Left) *Sagittal plane CBCT shows a small supernumerary tooth apical to this cleft palate patient's lateral incisor on the unaffected side ➡. There was also an additional erupted lateral incisor ➡.* **(Right)** *Cropped panoramic radiograph demonstrates multiple unerupted teeth in a mixed dentition patient with cleidocranial dysplasia. It is often difficult in these patients to differentiate supernumerary teeth from the normal developing dentition. Supernumerary teeth ➡ in the mandible have been identified.*

Cleidocranial Dysplasia

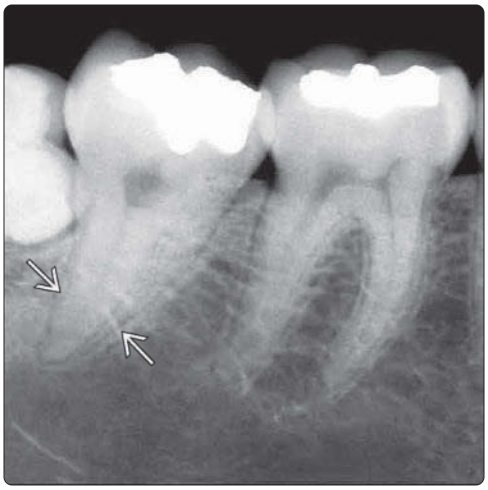
Gardner Syndrome (Familial Adenomatous Polyposis)



(Left) *3D CBCT reconstruction shows multiple supernumerary teeth in the maxilla of this 14-year-old girl with cleidocranial dysplasia. CBCT is helpful in determining morphology and developmental stage of the unerupted teeth for orthodontic treatment planning.* **(Right)** *Cropped panoramic radiograph shows multiple small, unerupted supernumerary teeth ⇨ in a patient with Gardner syndrome. Note the presence of an osteoma ➡ at the angle of the mandible. (Courtesy B. Pass, DDS.)*

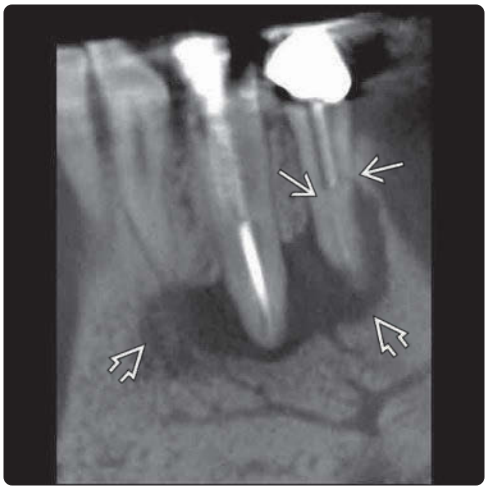
Internal Resorption

Fused Roots



(Left) *CBCT cross-sectional views show internal resorption presenting as extensive and fusiform pulp canal enlargement with palatal resorption in a maxillary central incisor (left) and balloon-like enlargement of the canal in a mandibular central incisor (right). Alteration in pulp canal morphology is diagnostic of internal resorption. (Courtesy M. Noujeim, DDS.)* **(Right)** *Periapical radiograph depicts fused roots on the mandibular right 2nd molar. Most mandibular molars have 2 distinct roots.*

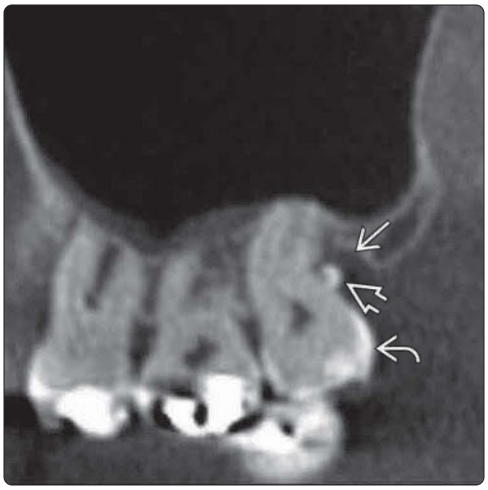
Root Fractures



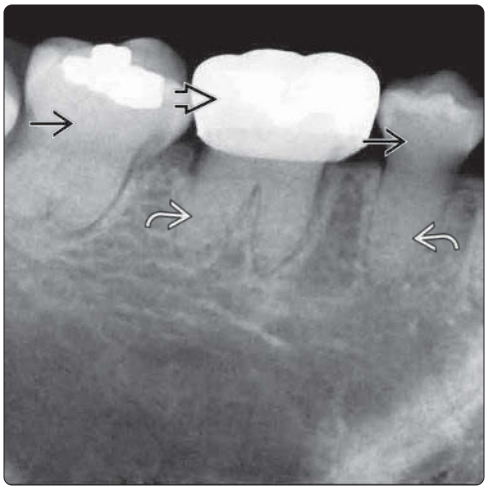
Supernumerary Roots

(Left) *Sagittal oblique CBCT exhibits a root fracture on the left mandibular 1st premolar. The fracture lines coincide with the junction of the post and root filling. This is a common site of fracture in endodontically treated teeth. The resulting apical pathosis is extensive.* **(Right)** *Sagittal 3D CBCT viewed from the lingual exhibits a 3-rooted mandibular 2nd molar (radix entomolaris).*

Enamel Pearls

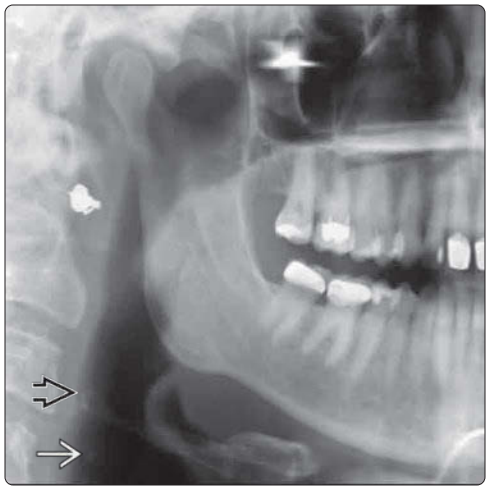


Dentinogenesis Imperfecta

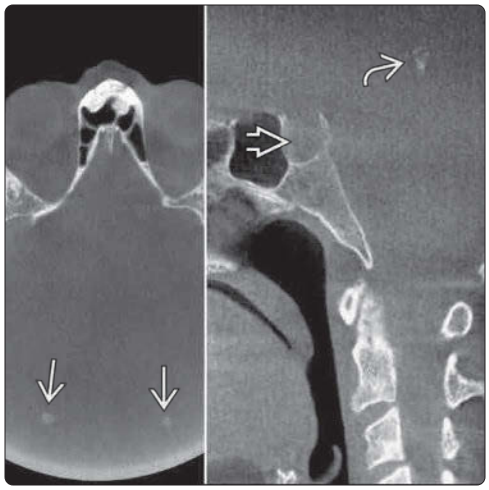


(Left) *Sagittal reformat CBCT shows a left maxillary 3rd molar with enamel pearl at the furcation area, the most common location for enamel pearls. Note the density of the pearl is identical to enamel. There is adjacent vertical periodontal bone loss. (Courtesy M. Noujeim, DDS.)* **(Right)** *Periapical radiograph shows generalized short roots in this patient with dentinogenesis imperfecta. Note the stainless steel crown on 1st molar, most likely a protective measure. Note the absence of pulp chambers and canals.*

Calcified Triticeous Cartilage

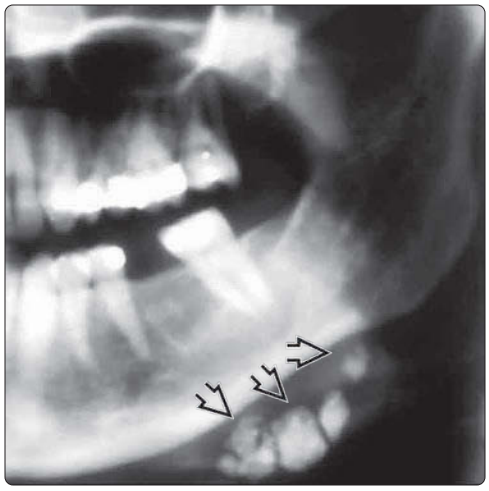


Intracranial Calcifications

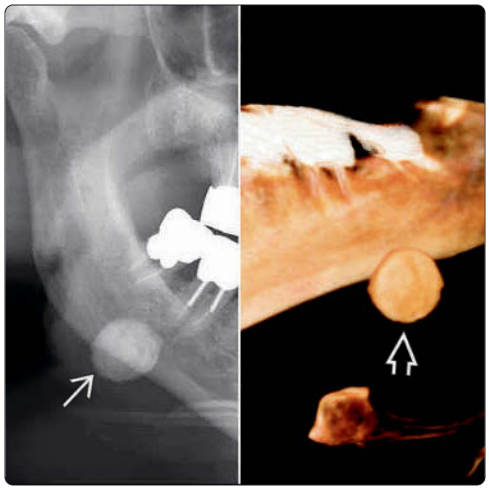


(Left) *Panoramic radiograph shows calcified triticeous cartilage inferior to greater cornu of hyoid. Triticeous means grain of wheat. When calcified, it appears as small, round or oval radiopacity, differentiating it from carotid atheroma, which appears irregularly linear.* **(Right)** *Axial CBCT (left) shows bilaterally symmetric, round calcifications, likely in lateral ventricle, consistent with calcified choroid plexus. Sagittal CBCT (right) shows calcification of pineal gland. Note midline location, posterosuperior to sella.*

Calcified Lymph Node

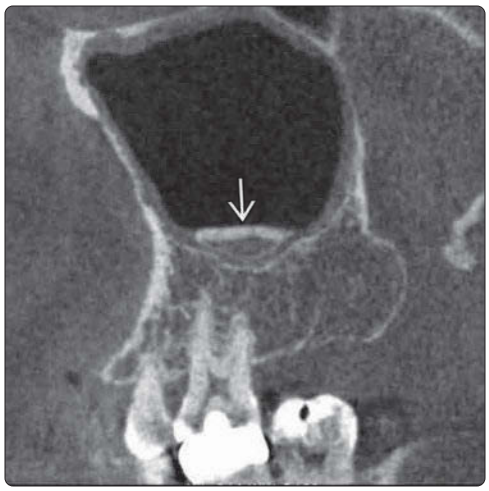


Sialolith

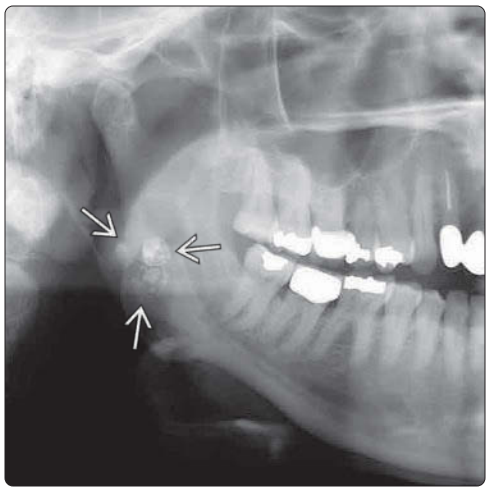


(Left) *Cropped panoramic radiograph shows multiple irregular, cauliflower-like radiopacities inferior to the left mandible. Note the irregular outline compared to a submandibular sialolith. These calcified submandibular nodes were palpable.* **(Right)** *Panoramic radiograph shows round radiopacity over the inferior border of the right mandible. Differential includes a calcified lymph node but the smooth border favors a sialolith. CBCT reformat, viewed medially, reveals lingual location in the submandibular gland area.*

Antrolith

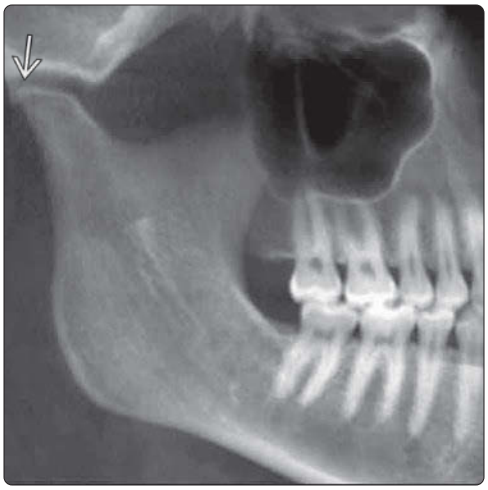


Tonsillolith



(Left) *Sagittal CBCT exhibits linear calcification in the mucoperiosteum of the left maxillary sinus. It is important to differentiate opacities associated with inflammatory sinusitis from fungal sinusitis, which exhibits finer, punctate calcifications. (Courtesy M. Noujeim, DDS.)* **(Right)** *Panoramic radiograph shows multiple radiopacities superimposed over the right ramus. Parotid calcifications are in the differential but are more likely to ghost in panoramic images. CBCT location was consistent with palatine tonsilloliths.*

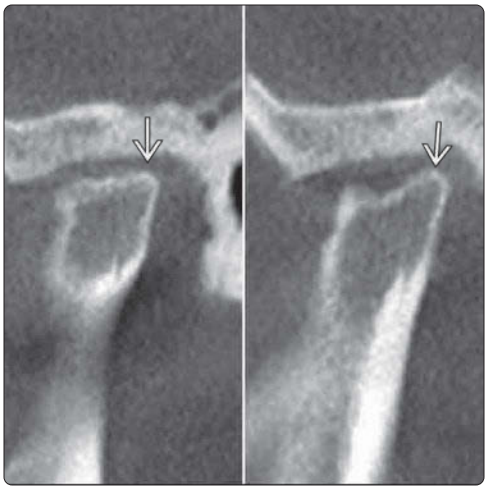
Rheumatoid Arthritis



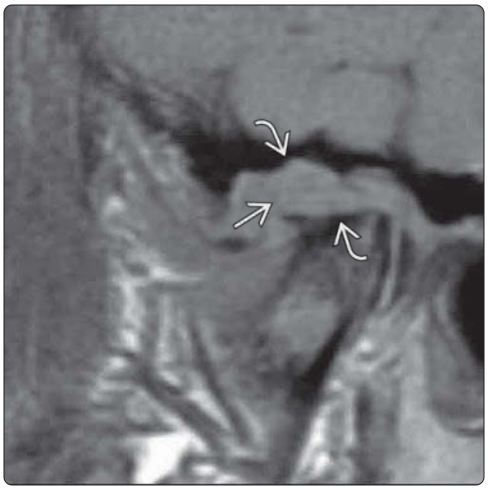
Rheumatoid Arthritis

(Left) *Panoramic reformatted CBCT shows reduction of condylar size due to rheumatoid arthritis. There is a sharpening of the condylar (pencil-shaped) that is often seen in this condition.* **(Right)** *Panoramic reformatted CBCT in the same patient shows rheumatoid arthritis affecting both TMJs, as is usually the case with this condition. The inflammatory process affects both the condyle and the fossa.*

Rheumatoid Arthritis

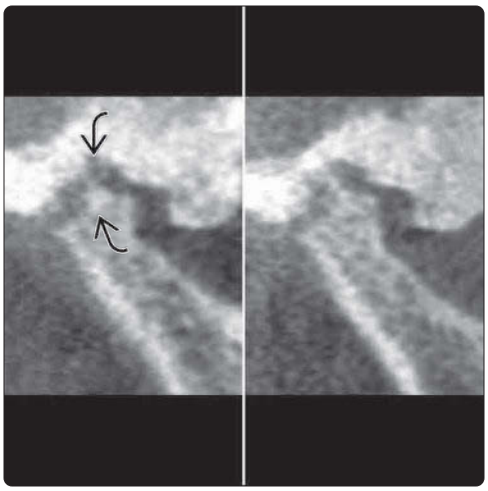


Rheumatoid Arthritis

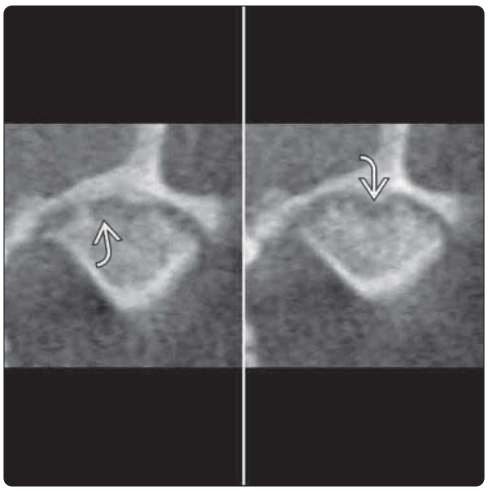


(Left) *Sagittal oblique CBCT cross sections in the same patient show both flattening and irregularity of the superior aspect of the condyle with sharpening of the condyle.* **(Right)** *Sagittal oblique T1 MR shows the pannus formation in the joint space destroying the articular surfaces of the fossa and condyle.*

Rheumatoid Arthritis



Rheumatoid Arthritis



(Left) *Sagittal oblique CBCT of the right condyle shows the irregular articular surfaces of the fossa and condyle, often seen with rheumatoid arthritis. Reduction of condylar height and volume occurs due to this inflammatory process.* **(Right)** *Coronal oblique CBCT in the same patient shows the irregular articular surfaces, condylar size reduction, and narrowing of the joint space.*