# ORAL AND MAXILLOFACIAL RADIOLOGY

## *A DIAGNOSTIC APPROACH*

# Part 1
# Introduction

# Chapter 1
# Basics of radiological diagnosis

## Introduction

The clinician should understand how the image is made and the normal anatomy and its variants in order to be able to identify artifacts, particularly those that can mimic the appearance of disease. Although these elements, as they present on *conventional radiography*, are addressed in detail by the wide range of dental radiology texts currently available, this textbook's figure legends note features caused by incorrect panoramic technique, artifacts, and variations of normal radiographic anatomy. Figure 1.1 outlines the main attributes of the imaging modalities that are featured in this textbook. These imaging modalities have been broadly divided into conventional radiography and advanced imaging.

Diagnosis in oral and maxillofacial radiology is most frequently based both on the clinical findings (including presenting complaint and history) and on the features observed on conventional radiographs. A definitive diagnosis is possible for a large proportion of lesion types that present to the primary care dentist. These lesions do not include just those lesions of inflammatory origin that present as periapical radiolucencies (on histological examination: *granuloma*, *periapical cyst*, or periapical abscess) and *condensing osteitis*, but also *dentigerous cysts* and *dense bone island* (also known as *idiopathic osteosclerosis*). They are not only the most frequently occurring lesions affecting the jaws, but a majority of them also have distinctive clinical and radiological presentations. Some other lesions such as *florid osseous dysplasia*, the *cementoblastoma*, the *compound odontoma*, and some cases of *odontogenic myxoma* can be definitively diagnosed solely on their radiological appearance. In those situations where a definitive diagnosis is not possible, a differential diagnosis should be developed. This will consist of two or more lesions. Such cases are frequently referred to a specialist as much for a diagnosis as for treatment. In order to assist the reader in his/her diagnosis this textbook is illustrated throughout with diagnostic flowcharts.

There is an expectation that the images created should adequately display the area of clinical interest with the purpose of addressing those clinical questions that indicated the need for the investigations. Thus the image or images should display the entire area of pathology and be free of artifacts. Therefore, an unerupted third molar should not only include the entire tooth and its follicle, but also at least a clear margin of 1 mm around them. This would allow the clinician to determine whether it is close to the mandibular canal or any other adjacent structure.

An example of inadequacy of the radiography resulted in a Canadian dental malpractice case that continued for 12 years through at least five courts before it was concluded, presumably settled.[1] The only positive result of this failure to include only 98% of a third molar was its not insignificant contribution to Canadian law specifically and common law in general. From reading the case it is abundantly clear that if an adequate radiograph or radiographs had been taken in the first instance this case would have had little grounds upon which to proceed, and the spilling of so much legal ink and personal and professional distress would have been avoided.

Radiographs are prescribed for three reasons, diagnosis, presurgical planning and follow-up. Those prescribed for the purpose of diagnosis and/or presurgical planning should be made prior to biopsy because this can change the radiology of the lesion appreciably. This is particularly so with regard to advanced imaging such as *helical computed tomography* (HCT) and *magnetic resonance imaging* (MRI). Two cases demonstrate the effects of biopsy prior to HCT.

The biopsy of an odontogenic myxoma, a locally invasive benign neoplasm, prior to HCT,

**Modalities used in oral and maxillofacial radiology**

**Conventional Radiography**
Advantage:
Majority of jaw lesions (*Chapters 9 & 10*) are diagnosed radiologically because of
*Superior spatial resolution*
*Cost—low*
*Access—easy & widely available*
Disadvantage:
2-dimensional image of a 3-dimensional structure—superimposition

**Intraoral radiography**
*Remarks*
*1. Best spatial resolution*

**Panoramic radiography**
*Remarks*
*1. Moderate spatial resolution*
*2. Overview of jaws*
*3. Distortion in horizontal plane*

**Advanced Imaging**
Cross-sectional and 3-dimensional imaging
Advantages:
1. primary diagnosis of lesions affecting:
*Maxillary antrum (**Chapter 11**)*
*Facial fractures (**Chapter 14**)*
*Lesions of the base of the skull and the soft tissues of the head and neck (**Chapter 16–18**)*
2. Refines differential diagnosis acquired by conventional radiography of the jaws
3. Optimizes treatment planning
*Displays full extent of lesion*
*Permits more accurate measurement*
Disadvantage:
Poor spatial resolution

**Ionizing radiation**

**X-ray generator**
Computed tomography

*Fan-beam*

*Cone-beam*

**Helical CT(HCT)**
*Chapter 4*
*Remarks*
*1. Bone, soft-tissue and air windows*
*2. Can use supine with i.v. contrast*

**CBCT**
*Chapter 5*
*Remarks*
*1. Bone window only*
*2. Better spatial resolution than HCT*

**Annihilation radiation**
Positron emission tomography (PET)
*Chapter 7*
*Remarks*
*1. Detection of unknown primary*
*2. Distant metastasis*

**Magnetic resonance imaging (MRI)**
*Chapter 6*
*Remarks*
*1. T2 best for pathology*
*2. Bone and air are 'black'*
*3. Fat is also 'black' if fat saturated*
*4. Can use i.v. contrast*
*5. Modality of choice for temporomandibular dysfunction **Chapter 12***

**Ultrasonography**
*Chapter 8*

Grayscale
*Remarks*
*1. Measurements*
*2. Salivary glands **Chapter 13 & 17***
*3. 3-dimensional currently only in obstetrics*

Doppler
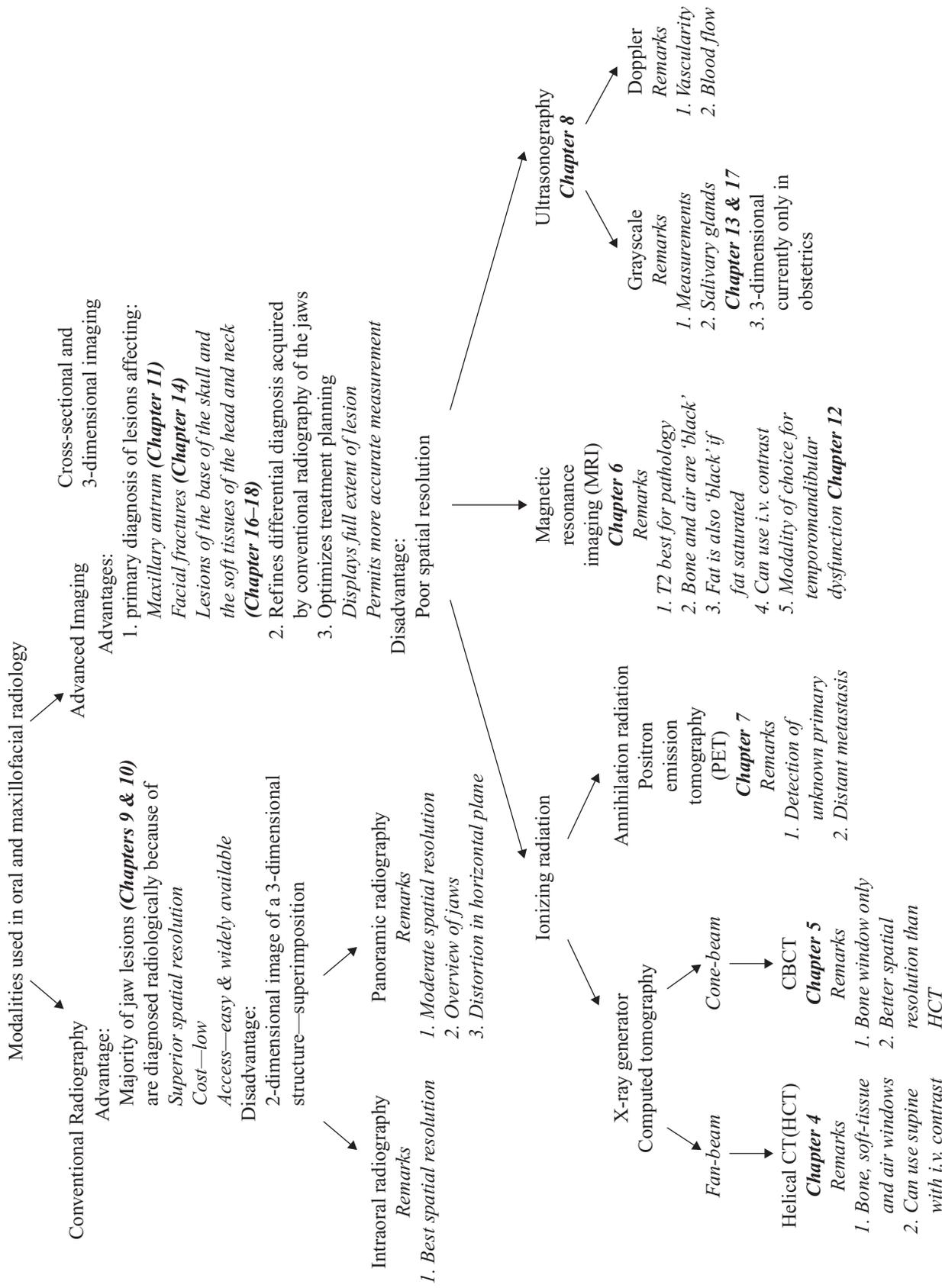*Remarks*
*1. Vascularity*
*2. Blood flow*

**Figure 1.1.** The modalities used in oral and maxillofacial radiology. This is an overview of the main imaging modalities, including remarks concerning their clearest clinical uses, relative advantages over other modalities, and limitations of use.
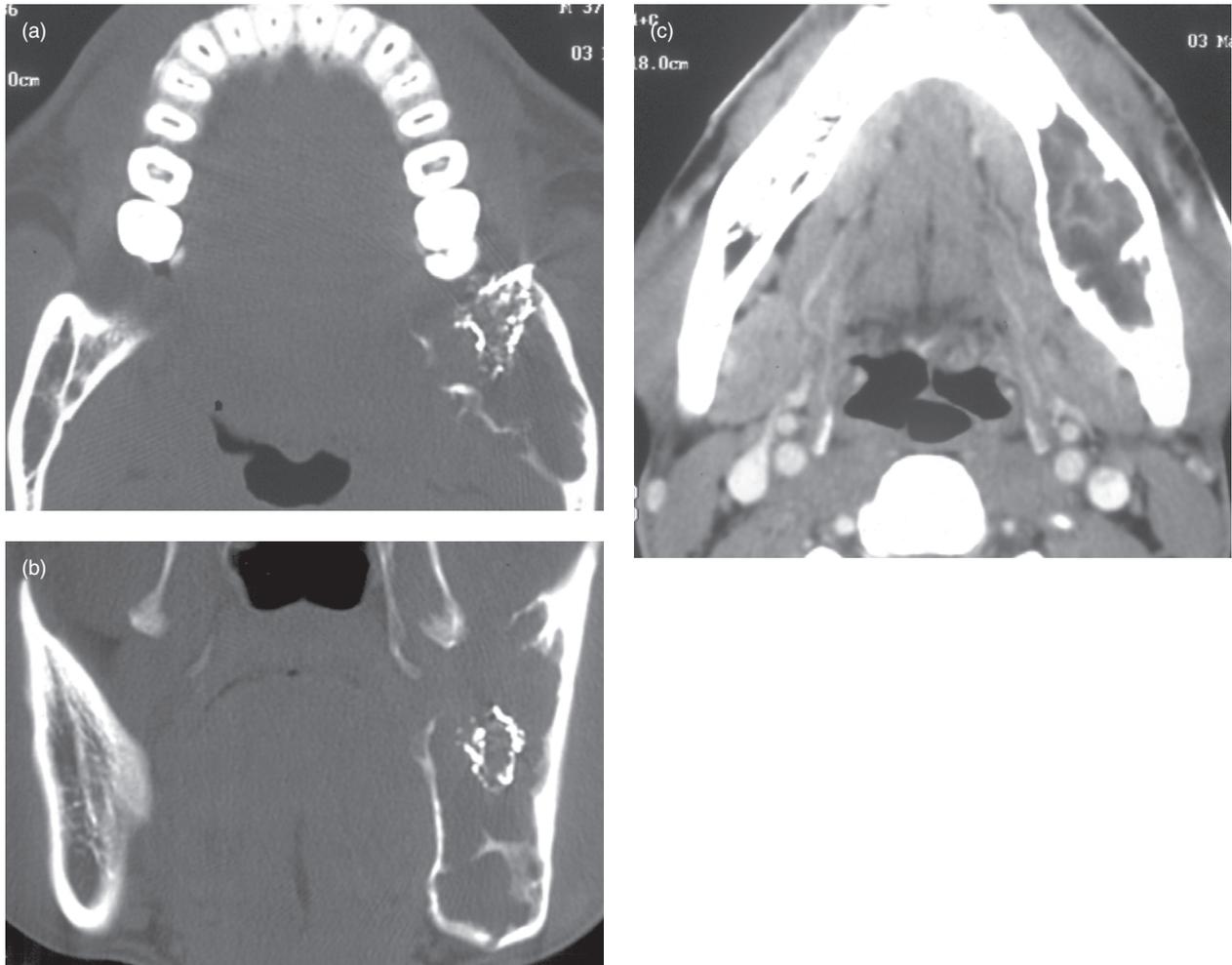
**Figure 1.2.** A computed tomograph of an *odontogenic myxoma* carried out after the lesion had been biopsied. The biopsy site still has its dressing in place (Figure 1.2a and 1.2b). As a result there was enhancement (Figure 1.2c) by the intravenous contrast at the site biopsied that is more likely to reflect hyperemia in response to the trauma of surgery. **Note:** All the major blood vessels including the facial and lingual arteries are enhanced in Figure 1.2c. Figure 1.2c reprinted with permission from MacDonald-Jankowski DS, Yeung R, Li TK, Lee KM. Computed tomography of odontogenic myxoma. *Clinical Radiology* 2004;59:281–287.

provoked an inflammatory response within the depth of the lesion, which was enhanced by the intravenous contrast (Figure 1.2). Contrast is recommended for lesions, which include a neoplasm or a vascular lesion in their differential diagnosis. This, with regard to neoplasms, is important to determine local invasion of adjacent soft tissues, which would need to be resected along with the rest of the neoplasm.

Figure 1.3 displays a case of *fibrous dysplasia*, which caused a substantial expansion of the affected mandible. When it was first seen by general surgeons unfamiliar with its manifestation in the jaws they performed multiple biopsies. These biopsies created their own artifacts on a subsequent HCT. These artifacts were loss of cortex and dysplastic tissue exuding through a biopsy site.

Conventional radiography will be the first imaging modality to be prescribed to investigate further a lesion occurring within the bony jaws obvious to or suspected by the clinical history and/or examination. For the majority of lesions affecting the jaws, conventional radiography is likely to be the sole imaging modality deemed clinically necessary. The principal advantages of conventional radiography are its superior spatial

**Figure 1.3.** This is a bone-window axial computed tomography of *fibrous dysplasia* affecting the vertical ramus of the mandible. The cortical defects are the result of several biopsies performed prior to referral for computed tomography. Such operations can largely invalidate any clinically important radiological findings because these, if erroneous, could lead to a wrong diagnosis and inappropriate treatment. **Note:** Radiology is very central to the diagnosis of specific *fibro-osseous lesions*, discussed later.

resolution (especially of the intraoral technologies), low radiation dose, and low cost. It is also available in the dental office or surgery. It is most likely that this prescription will include a panoramic radiograph that may be accompanied by intraoral radiographs. These images may be in either analogue (film) or digital format. An overview of the various conventional radiographic technologies is set out in Table 2.1. The panoramic radiograph permits an overview of the jaws from condyle to condyle. It also permits comparison between sides. These premises can be valid only if the patient is properly positioned within the panoramic radiographic unit exposed by the most appropriate exposure factors and the image is properly developed. Finally it is also expected that the resultant image is properly reviewed (read) under optimal viewing conditions (see Chapter 2). To reiterate, all prescriptions for a radiological investigation must be based upon a thorough clinical examination. Although there is little, if no, place for routine radiographic screening in the modern practice of dentistry, every image

should be carefully reviewed to identify any pathology that may be incidental to the patient's complaint and the results of the clinical examination.

The panoramic radiograph in addition to permitting determination of the specific features of the lesion or suspected lesion that prompted its making, can also reveal macroscopic abnormalities such as size differences and changes in a specific anatomical location (Figure 1.4) Furthermore, it can compliment the clinical examination by confirming defects in the dental development, such as the number, eruption, size, and even structure of the teeth (Figure 1.5). Because these features have been fully addressed in other texts and are generally well understood, space constraints preclude offering images of them here.

The various lesions, occurring within the face and jaws, often present with similar features at certain stages. Most will at some stage present as a radiolucency as they create space for further growth within the bony jaws. The borders of this radiolucency give a further clue as to their intrinsic behavior. Encapsulated benign neoplasms and many uninfected cysts grow at a moderate pace and are generally well defined. They may even have a cortex. Infected lesions and malignancies are generally associated by a poorly defined margin reflecting their more aggressive infiltrative expansion into previously normal bone. Sometimes, if the infected lesion becomes less virulent the adjacent bone may respond by laying down more bone on the trabeculae resulting in sclerosis.

Slow-growing lesions, such as most cysts and encapsulated neoplasms, can displace teeth and adjacent structures such as the mandibular canal and cortices. More aggressive lesions are more likely to resorb them. Some malignancies, such as a *squamous cell carcinoma*, will destroy structures with very little displacement, whereas others will provoke a periosteal reaction such as the onion layer typical of *osteogenic sarcoma* or *Ewing's tumor*. Such periosteal reaction can occur in *chronic osteomyelitis*. Such periosteal reactions are frequently seen in the extragnathic skeleton[2] but are infrequently seen in the jaws.

After the lesion has been properly imaged and reviewed the clinician reaches the point at which s/he wants to identify the lesion. Because the aim at this stage is to achieve, if possible, a definitive diagnosis it follows that this is best accomplished if the images of the lesion have been scrupulously reviewed. To this end I developed the rule of the
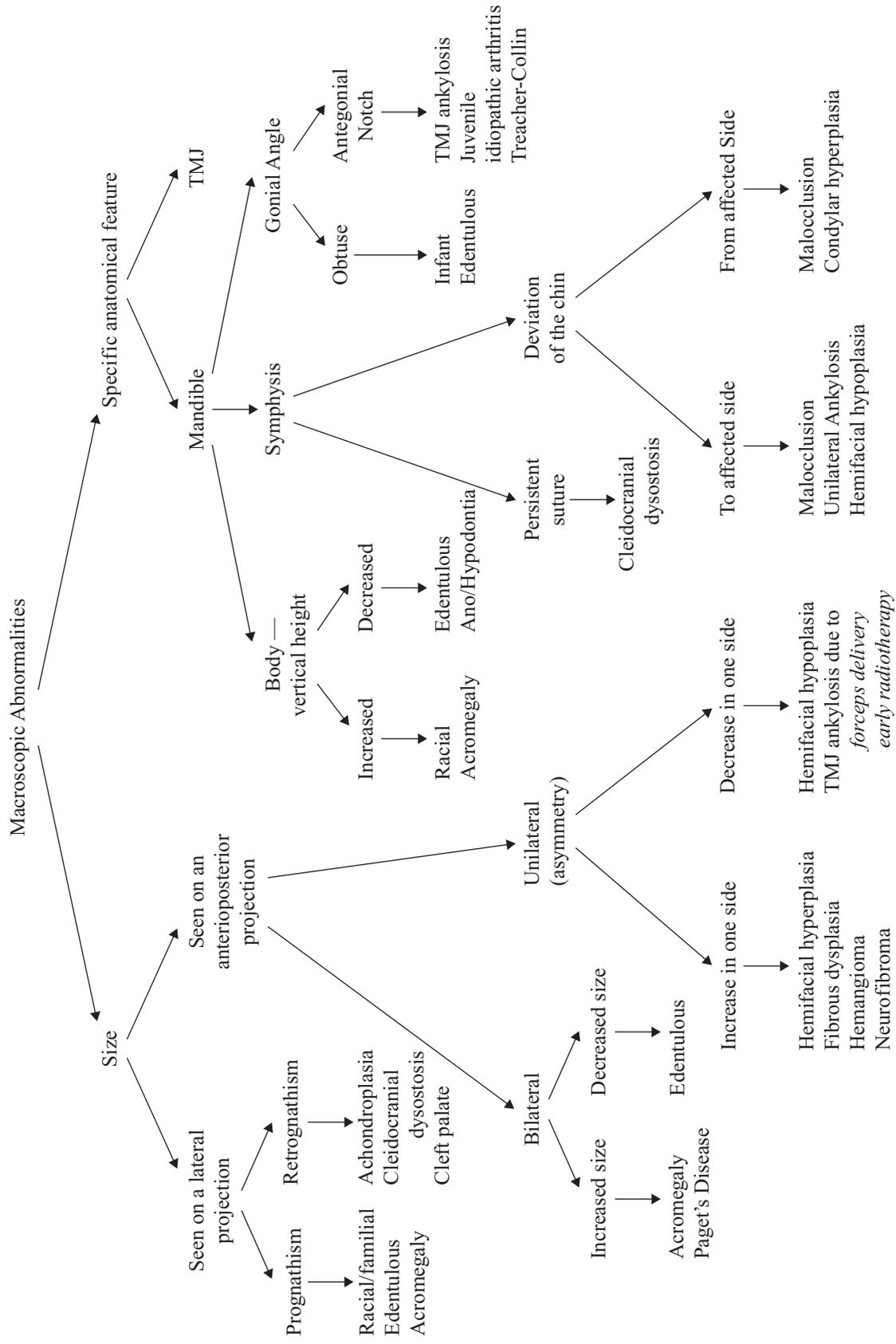
Macroscopic Abnormalities

Specific anatomical feature
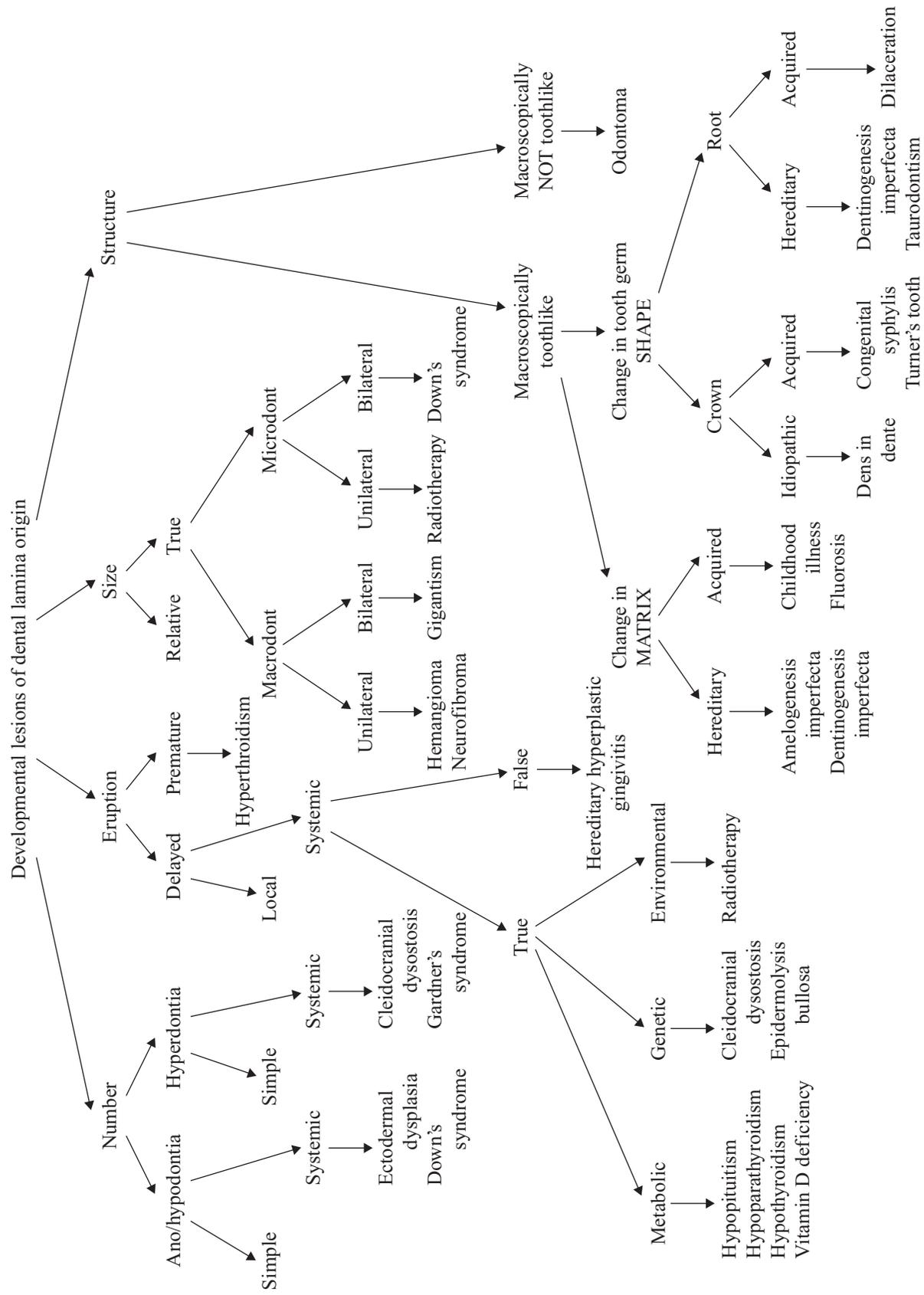
TMJ

Mandible

Gonial Angle

Antegonial Notch → TMJ ankylosis / Juvenile idiopathic arthritis / Treacher-Collin

Obtuse → Infant / Edentulous

Symphysis

Deviation of the chin

From affected Side → Malocclusion / Condylar hyperplasia

To affected side → Malocclusion / Unilateral Ankylosis / Hemifacial hypoplasia

Persistent suture → Cleidocranial dysostosis

Body — vertical height

Decreased → Edentulous / Ano/Hypodontia

Increased → Racial / Acromegaly

Size

Seen on an anterioposterior projection

Unilateral (asymmetry)

Decrease in one side → Hemifacial hypoplasia / TMJ ankylosis due to *forceps delivery* / *early radiotherapy*

Increase in one side → Hemifacial hyperplasia / Fibrous dysplasia / Hemangioma / Neurofibroma

Bilateral

Decreased size → Edentulous

Increased size → Acromegaly / Paget's Disease

Seen on a lateral projection

Retrognathism → Achondroplasia / Cleidocranial dysostosis / Cleft palate

Prognathism → Racial/familial / Edentulous / Acromegaly

**Figure 1.4.** Classification of macroscopic abnormalities.

9

**Figure 1.5.** Classification of developmental lesions of dental lamina origin.

"Five S's" (shade, shape, site, size, and surroundings) and its ancillary "Three D's" (diameter, density, and displacement. There are many lesions that can be definitively diagnosed at this stage, but many others require further investigations, which could include advanced imaging.

In order to ensure that the most appropriate investigations are applied, the provisional diagnosis should be restricted to no more than 3 lesions if possible, placing the most likely in the first position so the most appropriate investigation can be performed to determine whether it is that lesion. An important exception to this "most likely" rule is potential seriousness of outcome of the lesions. Table 1.1 compares clinical outcomes according to a 10-step (0 through 9) hierarchy of seriousness of outcomes. The higher placed lesions have the more serious outcomes.

The selection of the lesions can vary among clinicians depending upon that particular lesion's presentation and frequency within a particular clinician's patient pool. The age, gender, and ethnic origin of the particular patient and site of predilection are perhaps overemphasized in most teaching programs. The main problem with this is that many lesions frequently present first outside their expected age ranges. Occasionally, this expected age range may simply be out of date. An example is fibrous dysplasia; the majority in a recent systematic review first presented in the third decade and older. If the predilection of a lesion is less than 80% for a particular feature, its value as a major diagnostic tool should be discounted unless it may hint at a serious lesion that should not be overlooked or inappropriately treated. One such lesion is the *ameloblastoma*, the most common odontogenic neoplasm globally. This 80% limit is reflected in the *receiver operating characteristics' (ROC) area under the curve (AOC).*[3]

Another source for inaccuracy is that lesions are often superficially reported as *relative period prevalence* (RPP), which is not only dependent upon their proportion but on that of the other lesions within the same group of lesions, such as odontogenic neoplasms. The RPP not only varies between communities,[4] but it is also dependent upon the edition of the *World Health Organization* (WHO) classification of odontogenic neoplasms used. Many previously classified odontogenic neoplasms are no longer formally considered as such. An example is the cementifying fibroma (then later combined with the "ossifying fibroma", previously considered to be a separate lesion, as the *cemento-ossifying fibroma*),

once considered by the 1971 WHO edition[5] to be an odontogenic neoplasm is now considered to be a wholly osseous neoplasm, the ossifying fibroma. Some other lesions are reclassified as neoplasms. The *parakeratotic variant of the odontogenic keratocyst* is now, according to the 2005 WHO edition,[6] *keratocystic odontogenic tumor*, a neoplasm and thus no longer a cyst, whereas the orthokeratotic variant remains a cyst, the *orthokeratinized odontogenic cyst*. The same has also happened to the *calcifying odontogenic cyst*, which is now according to the 2005 edition the *calcifying cystic odontogenic tumor*. Such changes render RPP increasingly unreliable.

After a diagnosis has been made the clinician has a choice of three broad approaches to the lesion's management. These have been summarized in the rule of the 3 R's. *Refer* (to an appropriate colleague) and *review* are obvious, whereas *recipe* (treatment) requires an explanation. This is derived from the apothecary's "barred R," now often reduced to *Rx* derived from the Latin imperative *Recipe!* meaning *Take!* or *Receive!* This is still printed at the top-left corner of prescriptions for pharmaceuticals and/or other treatment.

The nomenclature used throughout will be, as far as possible, that used by the 2005 edition of the *World Health Organization Classification of Tumours*.[6] Common synonyms will appear in parentheses with the first appearance of each term in each chapter. As far as possible the morphology code of the *international classification of diseases for oncology* (ICD-O) will be provided along with the invaluable behavior codes ("/0" for benign; "/3" for malignant, and "/2" for uncertain). Although, the vast majority of lesions are diagnosed and treated in oral and dental practice solely on clinical and radiological criteria, the overwhelming majority of such lesions are sequelae of dental caries. There are many other lesions, such as cysts and neoplasms, in which a definitive diagnosis based on their histopathology is necessary.

## Radiological Features

The radiological features central to the diagnosis of oral and maxillofacial lesions are encapsulated as the Five S's and Three D's rules. Although the use of these rules is most apposite for conventional radiography, they can also be applied when viewing HCT's "bone-windows" (Chapter 4) or *cone-beam computed tomographic (CBCT)* images (Chapter 5).

**Table 1.1.** Scale of severity of outcomes/potential severity of outcomes of oral maxillofacial radiology*

9. ***Resection, but high likelihood of recurrence or metastasis***
   Poorly differentiated squamous cell carcinoma
   Osteosarcoma
   Fibrosarcoma
   Adenoid cystic carcinoma (neural spread)
8. ***Resection and lower likelihood of recurrence or metastasis***
   Well-differentiated squamous cell carcinoma (qualified by site)
   Chondrosarcoma
   Ameloblastic carcinoma
   Mucoepidermoid carcinoma
7. ***Resection and likelihood of recurrence or metastasis rare***
   Solid ameloblastoma
   Verrucous carcinoma
   Odontogenic myxoma
6. ***Enucleation and cytotoxic treatment (Carnoy's solution)***
   Unicystic ameloblastoma (provided not affecting posterior maxilla)
   Keratocystic odontogenic tumor (KCOT formerly the parakeratotic variant of keratocyst)
5. ***Simple enucleation and high chance of recurrence (recurrence rate of 10% and over)***
   Aneurysmal bone cyst (ABC)
   Ameloblastic fibroma
   Ossifying fibroma (OF)
   Glandular odontogenic cyst (GOC)
   Cementoblastoma
   Pleomorphic (salivary) adenoma (PSA)
   Calcifying epithelial odontogenic tumor (CEOT)
   Calcifying cystic odontogenic tumor (CCOT)
4. ***Simple enucleation and little chance of recurrence***
   Adenomatoid odontogenic tumor (AOT)
   Ameloblastic fibro-odontoma
   Osteoblastoma/osteoid osteoma
   Orthokeratinized odontogenic cyst (formerly the orthokeratotic variant of keratocyst)
   Giant cell lesions, (large ones may need resection)
   Complex odontoma
   Squamous odontogenic tumor
   Warthin's tumor
3. ***Simple enucleation and no chance of recurrence (in a neoplastic fashion)***
   Periapical radiolucencies of inflammatory origin (either nonresponsive to orthograde endodontics or too large)
   Nasopalatine duct cyst
   Dentigerous cyst
   Compound odontoma
2. ***Conservative surgery may be required only to improve aesthetics***
   Fibrous dysplasia (surgery is not indicated unless compelled by appalling aesthetics or risk of blindness)
   Cherubism
   Condensing/sclerosing osteitis (no treatment required, but treatment of the affected tooth may result in regression)
1. ***No treatment generally required***
   Linqual bone defect
   Osseous dysplasia (florid and focal, but NOT familial or spontaneous forms)
   Retention pseudocyst
   Osteoma—solitary; nonsyndromal (ivory type could be surgically difficult)
   Traumatic/simple bone cyst
   Idiopathic osteosclerosis/dense bone island

*This table was inspired by the Richter scale for earthquakes. The scale is based on the general current treatment paradigms for each lesion.

## SHADE

Shade reflects the *radiodensity* of the lesion or feature under consideration and is its most obvious radiological attribute. This is readily reflected in the greatest frequency of radiodensity referred to in reports.

The radiodensity of a lesion observed by conventional radiography is usually described as one of three manifestations, *radiolucency, radiopaque,* and *mixed.* The radiolucency appears *black* and represents an absence of the bone type normal for that site (Figure 1.6).

The radiopacity appears *white* and represents an excess of mineralized tissue—frequently abnormal mineralized tissue (Figure 1.7). This abnormal tissue is usually laid down by cells (almost invari-

ably abnormal bone cells and their variants) due to dysplastic or neoplastic processes and may show some sort of structure. It is not always possible to determine the process by histopathology; three very different lesions, fibrous dysplasia (Figure
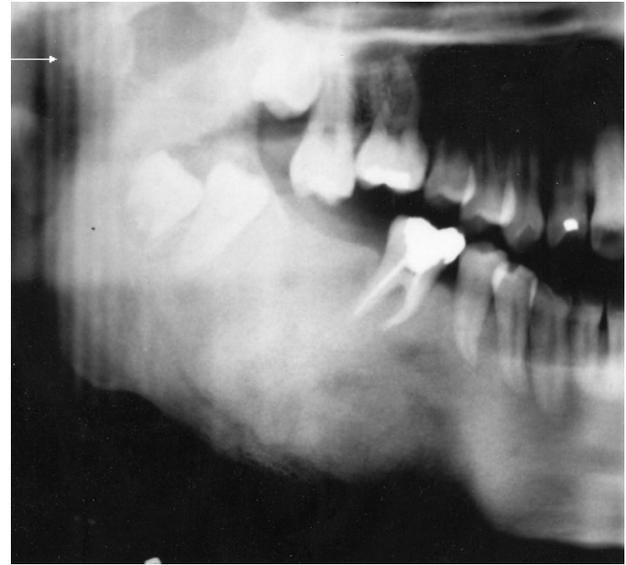


**Figure 1.7.** A panoramic radiograph displaying a generalized radiopacity of the posterior sextant. The mandibular canal has been reduced in thickness and displaced to the lower border of the mandible. Two unerupted molars are embedded within the vertical ramus. The lesion has expanded the body of the mandible vertically. This is *fibrous dysplasia.* **Note 1:** The mandibular canal is very obvious here as a radiolucent structure set against a background of abnormal (in this case dysplastic) bone. It has not only been displaced downward in this case, but also reduced in diameter and with a slightly irregular course. **Note 2:** The radiolucent presentation of the maxillary alveolus is a result of the superimposition of the air-filled oral cavity upon it. It may be prevented by instructing the patient to raise the tip of his/her tongue to contact the hard palate. **Note 3:** The secondary image of the contralateral mandible is superimposed upon the upper two-thirds of the vertical ramus. **Note 4:** The soft-tissue images of the soft palate and dorsum of the tongue are superimposed upon the upper third of the vertical ramus. The air space of the residual oral cavity between them presents as a radiolucent line, which has been mistaken to represent a fracture of the vertical ramus in other cases. Reprinted with permission from MacDonald-Jankowski DS. Fibrous dysplasia in the jaws of a Hong Kong population: radiographic presentation and systematic review. *Dentomaxillofacial Radiology* 1999;28:195–202.
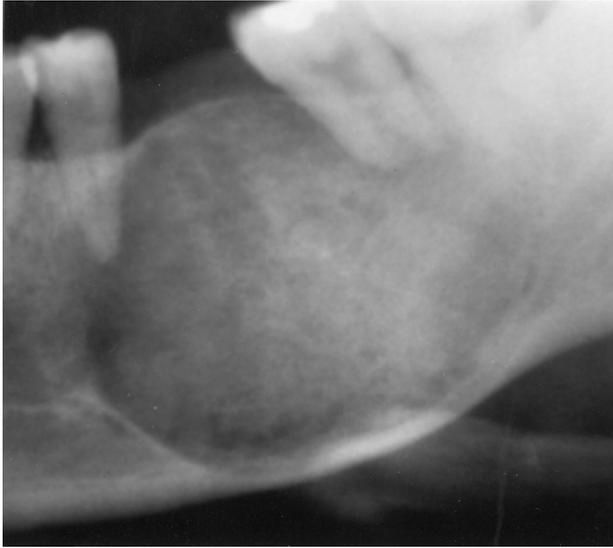


**Figure 1.6.** A panoramic radiograph displaying a well-defined unilocular radiolucency within the mandible extending from the right first molar's distal root to the junction between the contralateral canine and first premolar. The right lower border of the mandible has been eroded and displaced downward. The root of the right first premolar has been displaced distally. The root of the second premolar displays resorption. This is a *unicystic ameloblastoma.* **Note 1:** This panoramic radiograph had not been made using the optimal technique. It is in the head-down position. **Note 2:** The apparent root resorption or shortening of the teeth in the anterior sextant is most likely to be an artifact; due to its appearing outside the focal trough of the panoramic radiography. This happens particularly in the anterior sextant. **Note 3:** The horizontal band superimposed upon the roots of the right molars is the secondary image of the contralateral lower border of the mandible. Reprinted with permission from MacDonald-Jankowski DS, Yeung R, Lee KM, Li TK. Ameloblastoma in the Hong Kong Chinese. Part 2: systematic review and radiological presentation. *Dentomaxillofacial Radiology* 2004;33:141–151.

**Figure 1.8.** Panoramic radiograph displaying an *ossifying fibroma*. The lesion is well defined. It has a capsule of varying thickness. It has displaced downward the lower border of the mandible and displaced upward the alveolar crest. It has also displaced the mandibular canal toward the lower border of the mandible. It has displaced the root of the premolar forward and the roots of the molar distally. Its central radiodensity has a cotton wool pattern. **Note 1:** The partial superimposition of the hyoid bone on the lower border of the mandible is an indicator that the exposure had been made in the chin-down position. **Note 2:** The soft tissue of the gingival mucosa is observed in the edentulous space. Reprinted with permission from MacDonald–Jankowski DS. Cemento-ossifying fibromas in the jaws of the Hong Kong Chinese. *Dentomaxillofacial Radiology* 1998;27:298–304.

1.7), ossifying fibroma (Figure 1.8), and osseous dysplasia (formerly known as cemento-osseous dysplasia) (Figure 1.9) are entirely different lesions but display similar histopathological appearances, those of *fibro-osseous lesions*. This is discussed in detail in Chapter 10. Sometimes the bone is not *per se* abnormal but merely thickened trabeculae as found for idiopathic osteosclerosis (also known as dense bone islands) (Figure 1.10).

Occasionally mineralization can also be dystrophic; this is a deposition of mineral in soft-tissue lesions, such as calcification of lymph nodes (Figure 1.11), tonsils (Figure 1.11), sialoliths (Figure 13.6), antrolith acne scars, and so on. This is not laid down by bone cells but still may display some structure, usually as concentric layers of accretion (Figure 9.16).



**Figure 1.9.** The panoramic radiograph exhibits radiopacities in all four posterior sextants. The mandibular lesions are confined to the alveolar process; that is, they are found above the mandibular canal, which can be seen in places. This is a case of *florid osseous dysplasia*. **Note:** The relative radiolucency of the anterior sextant of the maxilla is due to the superimposition of the residual oral cavity.



**Figure 1.10.** This is a panoramic radiograph displaying a well-defined radiopacity associated with the root of the first premolar. The periodontal ligament space is intact and of regular thickness separating it from the radiodense bone. This tooth displays an intact crown; there are no caries or restorations. There is also no periodontal bone loss. The radiopacity is in direct contact with the adjacent normal bone; there is no radiolucency space between them. *Idiopathic osteosclerosis* is also known as a *dense bone island*.

**Figure 1.11.** A panoramic radiograph displaying a number of normal and abnormal radiopacities. Structures, which are normally composed of soft tissue, can present as radiopacities either by being silhouetted against air, as already seen for the soft palate and tongue, or becoming calcified. The latter can occur secondary to an infection. Classically this infection was tuberculosis. The calcified structures are the lymph nodes (cervical jugulodigastric and submandibular nodes) and the palatine tonsil (small opacities superimposed upon the mandibular foramen). This calcification is dystrophic. Another calcified, but almost always normal structure, is the styloid process. **Note 1:** The soft palate and tongue are clearly visible. **Note 2:** The horizontal band of a smeared radiopacity occupying the superior two-thirds of this image represents the contralateral mandible.

Radiopacities can arise from variants of anatomy such as mineralization of the stylohyoid complex (Figure 1.12). The normally (not mineralized) soft-tissue structures can be present, of which the easiest to recognize are the tongue and soft palate, on panoramic radiographs and lateral cephalograms (Figure 1.12). The ear lobe (Figure 1.12) is also very frequently apparent. Fractures can result in opacities if the fractured ends overlap (Figure 1.12). Incorrect panoramic radiographic technique (head-down) can result in the superimposition of the body of the hyoid on the mandible, resulting in a radiopacity (Figure 1.13a) instead of its usual submandibular position (Figure 1.13b).



**Figure 1.12.** A panoramic radiograph displaying a normal-sized styloid process (extends no lower than the mandibular foramen; see Chapter 10 for more details) and a calcified stylohyoid ligament reaching the hyoid bone. The lesser horn is presented as a round radiopacity superimposed upon the superior margin of the hyoid bone. These are also normal features. **Note 1:** The pinna of the ear is superimposed upon the styoid process. **Note 2:** The condyle is fractured and displaced anteriorly. As it overlaps the superior vertical ramus, an increased radiopacity occurs at the site of this overlap. **Note 3:** The black line delineating the line of the fractured condyle represents the Mach band effect and is discussed further in Chapter 3. **Note 4:** The soft palate and dorsum of the tongue are in contact and the radiolucent line observed in Figure 1.3 is substantially absent. **Note 5:** The superior half of the image is occupied by the secondary image of the contralateral mandible.

Mixed radiodensity describes a lesion presenting as a white area/s within a black area (Figure 1.14). This generally represents the deposition of mineralized tissue in an area where the bone type normal for that area had been previously removed to create space for the lesion, which subsequently undergoes mineralization.
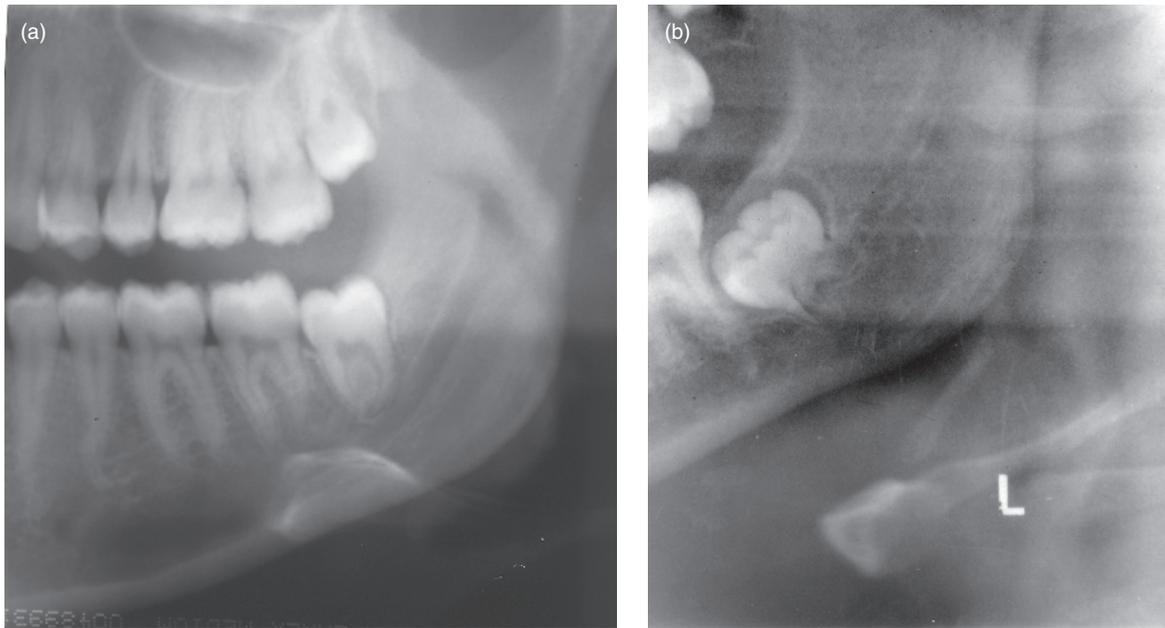
**Figure 1.13.** Panoramic radiographs displaying the hyoid bone. (a) Although this panoramic radiograph is correctly taken, the hyoid bone is superimposed upon the lower body of the mandible. This may be misinterpreted as a radiopaque lesion within the mandible. It is well defined and delineated by the black line of the Mach band effect. (b) The components of the hyoid bone, which are frequently apparent on panoramic radiographs and lateral cephalograms. The body and lesser and greater horns are observed as distinct entities. There are two depictions of the greater horn; the smaller and better detailed is the ipsilateral, whereas the longer and poorer detailed is the contralateral. The radiolucent area between the contralateral greater horn and the body represents the joint between them, which is frequently patent. **Note 1:** The secondary images of the contralateral mandible appear in both (a) and (b). **Note 2:** (a)There is a small air-filled space between the soft palate and the dorsum of the tongue, which is superimposed upon the mandibular foramen. **Note 3:** (b) The pinna of the ear.
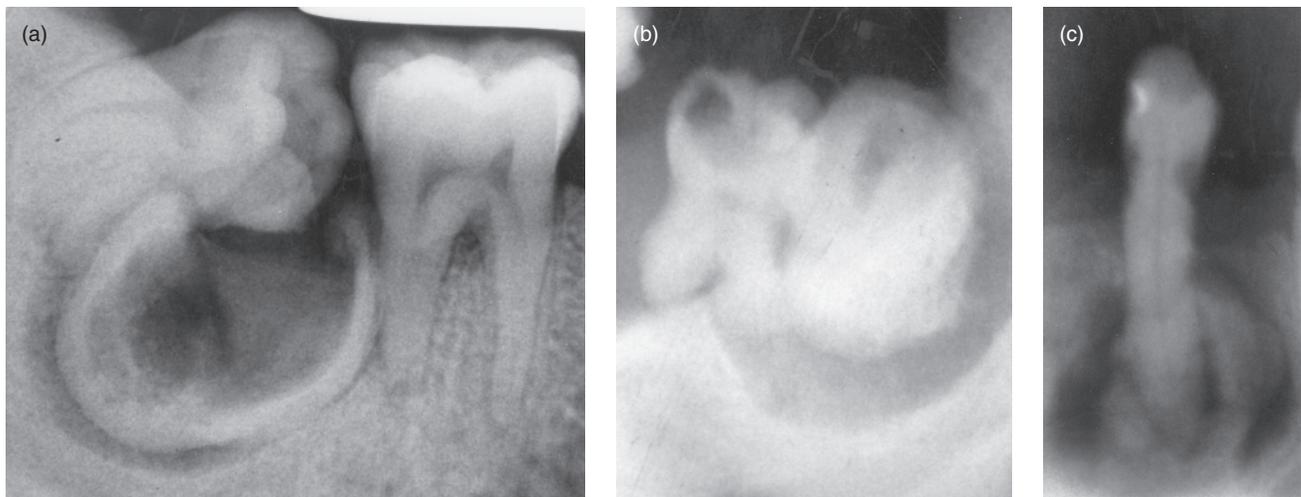


**Figure 1.14.** Panoramic radiographs displaying radiopaque lesions. (a) A well-defined radiolucency within which there is an annular (ringlike) radiopacity. This is an *annular odontoma*, which is a subset of the *complex odontoma*. (b) A well-defined radiolucency, associated with an almost wholly extruded molar tooth. Within the radiolucency and associated with the molar tooth is a well-defined radiopacity. This is a *complex odontoma*. (c) A radiolucency at the apex of an incisor. Within the radiolucency are several radiopacities. This is a case of *osseous dysplasia*.

Internal Structure

Trabecular Pattern

Septae

Blurred    Rarefaction    Increased Size    Abnormal Pattern

Movement
Osteomyelitis
Hemangioma

Sclerosing/Condensing osteitis
Idiopathic osteosclerosis
(Dense bone islands)

Focal    Generalized    Ground Glass → Peau d'Orange → Cotton Wool

Rarefying osteitis
Osteomyelitis
Carcinoma

Osteoporosis

Fibrous dysplasia
Ossifying fibroma
Osseous dysplasia

Paget's disease

Soap Bubble    Honeycomb    Tennis Racket

Odontogenic
myxoma

**Figure 1.15.** Internal structure of the lesion.

Those lesions that substantially present as radiolucencies are considered in Chapter 9, whereas those that most frequently present either complete radiopacities or as mixed lesions will be considered in the Chapter 10.

Having now determined that the lesion is radiolucent or at least partly radiopaque, consideration should then be given as to whether that radiopacity has an internal structure (Figure 1.15).

## SHAPE

The shape of a lesion may give a clue to its broad behavior. If it has a smooth rounded shape, it is *unilocular*. Although this shape is typical of less serious lesions such as inflammatory cysts and dentigerous cysts, which can be readily enucleated with a minimal tendency to recur, it is frequently seen of *unicystic ameloblastomas* (Figure 1.16). Sometimes a generally rounded shape may present with an undulating or scalloped periphery (Figure 1.17) typical of *simple bone cysts*.

Those lesions whose outline has been broken into loculi by "septae" are *multilocular*. This shape is indicative of more serious lesions, which require more radical treatment such as resection because of their marked propensity to recur. Such lesions are the *solid (multilocular) ameloblastoma*, keratocystic odontogenic tumor, and odontogenic myxoma. The multilocular radiolucency can present with three basic patterns; soap-bubble, honeycomb (Figure 1.18), and tennis racket (Figure 1.19). With the exception of the tennis-racket pattern, which is virtually pathognomic for the odontogenic myxoma, the other two patterns have so far not shown a particular predilection for any specific lesion.

The clinician should not confuse multilocular with scalloping (Figure 1.20)!

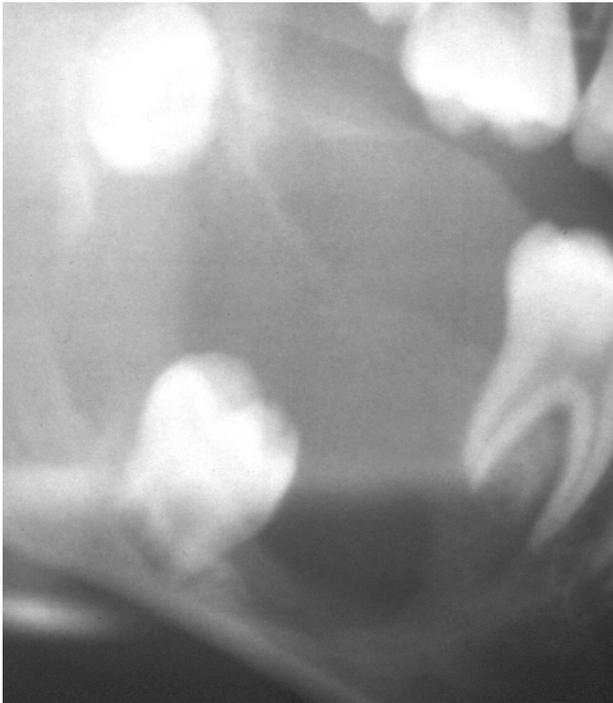It should be noted that for some lesions, particularly those cases observed in the younger patient

**Figure 1.16.** A panoramic radiograph displaying a well-defined radiolucency within the posterior sextant of the body of the mandible. Although there are 2 unerupted molars about its periphery, it is more intimately associated with the second molar, which has been displaced to the lower border of the mandible. The horizontally inclined third molar's follicular space is partially evident and is less likely to be contiguous with the larger lesion. The lesion almost wholly surrounds the second molar tooth, including its root. The absence of an attachment of the lesion at or within 1 mm of the cementoenamel junction (CEJ) and root resorption of the distal root of the first molar tooth suggest that the lesion is very unlikely to be a dentigerous cyst. This is a *unicystic ameloblastoma*. **Note 1:** The secondary image of the lower border of the mandible is partially superimposed upon the radiolucency. The inferior third displays the radiodensity that would have been obvious throughout the lesion if superimposition did not occur. The superior two-thirds displays a radiodensity, which is similar to the ground-glass appearance classically observed of fibrous dysplasia. This superimposition of the secondary image of the contralateral anatomy can be obviated on the panoramic reconstructions of computed tomography imaging. **Note 2**: The slightly more radiolucent superior third represents the substantial erosion or penetration of the cortex of the alveolar crest. The lesion immediately distal to the first molar is likely to be fluctuant.



**Figure 1.17.** This standard anterior occlusal projection (of the anterior sextant) of the mandible displays a well-defined radiolucency, which exhibits scalloping between the roots of the anterior teeth. Their lamina dura is intact and they do not exhibit root resorption. The superior portion of the lesion appears to be more translucent than the inferior portion, because of the superimposition of the mention. This is a *simple bone cyst*. Reprinted with permission from MacDonald-Jankowski DS. Traumatic bone cysts in the jaws of a Hong Kong Chinese population. *Clinical Radiology* 1995;50:787–791.

and smaller (thus may themselves be at an early stage in their life history), are generally unilocular, whereas those cases observed in the older patient and larger may appear multilocular. Therefore, multilocularity may represent the maturity of a lesion rather than its tendency to recur if inappropriately (enucleated rather than resected) or inadequately treated.

Most cysts and a few neoplasms display hydrostatic expansion to assume a round (spherical in three dimensions) or oval shape, whereas others may assume a spindle or fusiform shape. Although the latter is classically associated with fibrous dysplasia (Figures 1.21 and 1.22), it can be observed for some neoplasms, such as the odontogenic myxoma and the keratocystic odontogenic tumor.

## SITE

A solitary localized or single lesion suggests a local cause, whereas multiple lesions—particularly those affecting several sextants—suggest a systemic cause that could have general health implications. Although generally, if enough cases of a
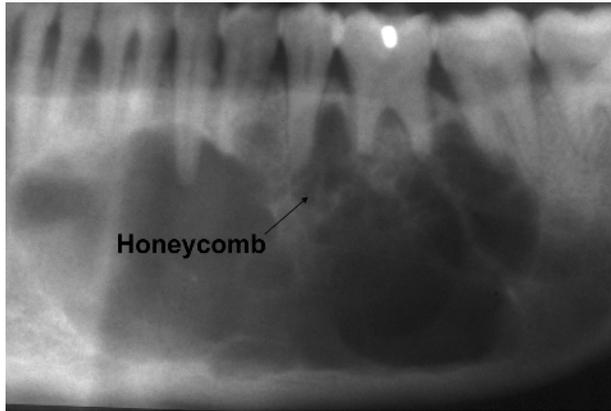
**Figure 1.18.** The panoramic radiograph shows a well-defined multilocular radiolucency extending from between the second molar and the junction between the contralateral canine and lateral incisor of the mandible. Many of the roots, particularly those of the first molar, display resorption, and those of the second molar are displaced distally. The lower border of the mandible has been both eroded and downwardly displaced. There are two multilocular patterns, the majority is of the soap-bubble pattern and a small area about the apex of the second premolar is of the honeycomb pattern. The latter is made up of multiple continuous cells of similar size, which together recall the appearance of a bee's honeycomb. This is a *solid ameloblastoma*. Reprinted with permission from MacDonald-Jankowski DS, Yeung R , Lee KM, Li TK. Ameloblastoma in the Hong Kong Chinese. Part 2: systematic review and radiological presentation. *Dentomaxillofacial Radiology* 2004;33:141–151.

lesion are reported they divide evenly between right and left, it is nevertheless important to record correctly this feature to avoid incorrect investigations or treatment for that particular patient. It is also clearly important to record correctly the jaw and sextants, not only for the above reason, but because some lesions have particular dispositions for a particular jaw and sextant.

Identify the affected jaw as the maxilla or mandible and the sextants as either anterior or posterior. The junction between the anterior (incisors and canines) and posterior (premolar and molars) sextants is arbitrarily defined by a vertical line passing between the canine and first premolar tooth.

Those lesions primarily affecting the maxillary antrum often present quite differently radio-

logically than they do in the mandible and anterior sextant of the maxilla. The lesions that affect the maxillary antrum will be considered separately in Chapter 11.

In order to determine between the alveolar and basal portions of the mandible, the relationship of the lesion to the mandibular canal should be reviewed. The equivalent feature for the maxilla is the hard palate. This is readily observed on panoramic radiographs or lateral cephalograms.

A lesion arising above the mandibular canal is in the alveolus and therefore likely to be an *odontogenic* lesion (see Figure 1.19), whereas a lesion below the mandibular canal is likely to be a *nonodontogenic* lesion (Figure 1.23). A lesion arising within the mandibular canal is likely to be a neural or vascular lesion. A lesion below the hard palate (esp. on panoramic radiographs) is likely to be an odontogenic lesion (Figure 1.24), whereas that arising above the hard palate is likely to be a nonodontogenic lesion (Figure 1.24).

If the lesion is in the alveolus, its relationship not only to teeth , but to a certain part of the tooth or teeth is important to refine further the differential diagnosis. If it is related to the crown of an unerupted tooth, this could suggest its origin within the follicle, whereas its relationship to the root of an erupted tooth with evidence of caries or periodontal disease could suggest an inflammatory cause and should provoke a testing of the pulp vitality of that tooth (pulp vitality testing is generally recommended for any tooth/teeth that are adjacent to a lesion). This clearly becomes less likely if the lesion is separated from the apex by a periodontal ligament space, which is represented by a near uniformly wide (0.2 mm) radiolucent line (Figure 1.25). The precise location of the lesion to the root is important; most inflammatory lesions are associated with the root apex, whereas this is less so if it is associated with the side of the root (Figure 1.26).

The *periodontium* is the overarching term for all tissues that surround and support the tooth. The *periodontal ligament space* is one of three components of the periodontium. The other two radiologically apparent components are the *lamina dura of the alveolar bone* and the *cementum of the root*. The main lesions that affect the periodontium have been set out in the flowchart in Figure 1.27. The length of the tooth directly affects the quality of the periodontium by determining the surface

**Figure 1.19.** The true occlusal projection of the anterior sextant of the mandible (a) and the axial (b) and coronal (c) computed tomographic sections (bone window) display the tennis racket multilocular pattern, which is virtually pathognomonic of the *odontogenic myxoma*. (a) The "strings" of the tennis racket appear to completely transverse the entire anterior sextant. Images (b) and (c) instead display the septae confined to the periphery of the lesion, leaving a central "atrium" completely free of septae. **Note 1:** The shape of the lesion recalls the fusiform shape typically observed in fibrous dysplasia affecting the jaws. **Note 2:** (b) The patency of the synchondrosis of the hyoid bone with the lesser horn immediately adjacent to it is readily displayed. **Note 3:** (b) Enhancement of the major blood vessels, but none of the lesion. Reprinted with permission from MacDonald-Jankowski DS, Yeung R, Li TK, Lee KM. Computed tomography of odontogenic myxoma. *Clinical Radiology* 2004;59:281–287.

**Figure 1.20.** Periapical radiolucency of the mandibular molars displaying a well-defined radiolucency associated with the apices of all three molars and the second premolar tooth. The alveolar-facing margin appears scalloped, whereas there is a septum on the inferior margin. As a result this lesion is now considered to be multilocular. At the apex of the second molar tooth is a radiopacity. This appears to be dysplastic. This is a *simple bone cyst* containing an area of *osseous dysplasia*. **Note:** The more translucent area in the center of the lesion represents perforation or at least significant erosion of either the buccal or lingual cortex or both. Reprinted with permission from MacDonald-Jankowski DS. Traumatic bone cysts in the jaws of a Hong Kong Chinese population. *Clinical Radiology* 1995;50:787–791.



**Figure 1.21.** A true occlusal projection of the mandible displaying *fibrous dysplasia*. A well-defined margin between the dysplastic and adjacent normal bone is absent. The gradual expansion of the lesion from the adjacent normal bone is apparent. This pattern of expansion recalls the shape of a spindle, hence fusiform. Both the buccal and lingual cortices are greatly reduced in thickness in comparison to the normal cortex anteriorly. The reduction in cortical thickness is gradual and reflects the broad zone of transition typical of fibrous dysplasia. The radiodensity can be observed to vary in pattern, from ground glass, peau d'orange, and cotton wool. The first two are apparent here.
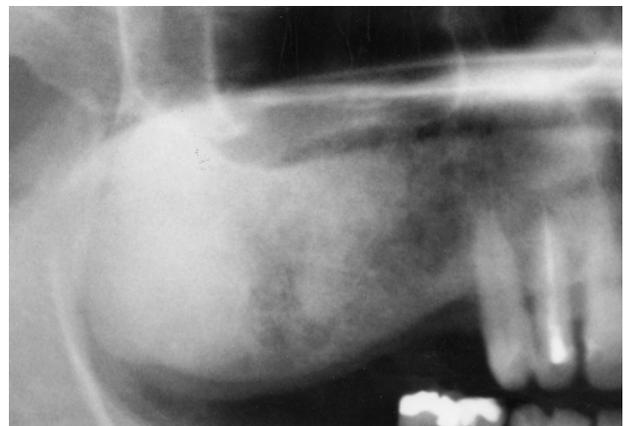
area available for periodontal fiber attachment. The size of the pulp in also entered both because the health of the root depends upon it, and it is just as easy to inspect it at the same time as the periodontium on the radiographs.

## SIZE

The size of a lesion can be rendered in metric units (imperial units are still used but increasing less so) or according to their anatomical boundaries (Figure 1.28). The latter is particularly necessary if the lesion is displayed on a panoramic radiograph. Not only is this modality subject to substantial magnification but also distortion, particularly in the horizontal plane.[7]

Another method for determining size from a panoramic radiograph is using "the dental unit." Each tooth and the mesiodistal width of bone it spans is one unit, except for each lower incisor,



**Figure 1.22.** Panoramic radiograph displaying *fibrous dysplasia* affecting the right hemimaxilla. It exhibits similar fusiform expansion as is apparent in Figure 1.21. The dysplasia has involved the lower part of the posterior antral wall.

**Figure 1.23.** Panoramic radiograph exhibiting a well-defined radiolucency between the mandibular canal and the lower border of the mandible. This is the classical presentation of the *lingual bone defect*. The more radiolucent center represents the ostium on the lingual cortex, which is narrower than the larger defect mushrooming out within the basal process of the posterior mandible. **Note 1:** The semi-inverted unerupted third molar tooth has a normal follicle. **Note 2:** It is likely that there is no root resorption of the distal root immediately adjacent to the unerupted tooth. Persuasive evidence for this contention is derived from observation of the periodontal margin on the distal aspect of this root, through the crown of the third molar. **Note 3:** The horizontal "break" in the lower border of the mandible is caused by the Mach band effect enhancement of the superimposition of the hyoid body upon it.



**Figure 1.24.** Panoramic radiograph displaying a soft-tissue opacity within the maxillary antrum. It is not associated with a carious or heavily restored tooth, which may suggest that the tooth's vitality has been compromised. This lesion is a *mucosal antral cyst,* also called a *pseudocyst.* **Note 1:** The hard palate (HP) presents as two images. The lower is its junction with the ipsilateral alveolus and the upper with the contralateral alveolus. **Note 2:** The soft tissue is visualized on a radiograph because it is silhouetted against the air-filled space of the maxillary antrum. This silhouetting is further enhanced by a black line around the mucosal antral cyst represents the Mach band effect. The same phenomena are associated with the visualization of the tongue, soft palate, and pharynx. **Note 3:** The root of the second premolar is still developing as evidenced by the presence of two "inverted chisels."

which counts for a half a unit. This can be extended into the ramus; the retromolar to the mandibular foramen, the mandibular foramen to the base of the condyle and coronoid processes, and the condyle and coronoid each account for one dental unit. This was recently used to compare the sizes of keratocystic odontogenic tumors as they appeared on a panoramic radiograph.[8] These give a reasonable estimate of the lesion's size, which may reflect an approach to surgery based on such units. Nevertheless, if surgery of a substantial lesion is contemplated, the use of advanced imaging, such as CT and MRI, permits very accurate measurements of lesions (Figure 1.29).

## SURROUNDINGS

The lesion's effect on its surroundings is twofold, the degree of marginal definition and the effect on adjacent structures.

The degree of definition of the normal adjacent tissue-lesion zone of transition should be, as far as possible, objectively assessed. This is important because marginal definition is the most important radiological feature after radiodensity. Failure to use a standard objective parameter can result in significant differences of opinion between clinicians affecting the differential diagnosis. One such objective definition of margin definition was that pro-

**Figure 1.25.** A standard anterior occlusal projection displaying an endodontically treated incisor. At its apex is a mature *osseous dysplastic* lesion. It may be surmised that the lesion presenting to the original clinician was that of a radiolucency. **Note:** It is not unusual to see such apical lesions associated with root-treated incisors. This suggests that the early radiolucent stage of this lesion had been mistaken for a periapical radiolucency of inflammatory origin. Pulp vitality is an essential investigation when the vitality of a tooth is questioned.



**Figure 1.26.** The periapical radiograph displays a well-defined radiolucency between the noncarious and pristine canine and first premolar tooth. A positive pulp vitality test ruled out a lateral radicular cyst. Other lesions that may give this presentation are remaining lesions in the differential diagnosis, the lateral periodontal cyst and the keratocystic odontogenic tumor (KCOT). At histopathology it was found to be the latter.

posed by Slootweg and Müller.[9] If s normal-adjacent tissue-lesion zone of transition is less than 1 mm, the lesion can be described as well defined and thus more representative of an uninfected cyst or benign neoplasm (Figure 1.30), whereas that which exceeds 1 mm is poorly defined suggestive of an inflamed lesion or a malignant neoplasm (Figure 1.31). This can be appreciated by running a 0.5 point pen around the periphery of the lesion displayed in an analogue format (film). If this can be achieved with ease then the margin is well defined.

Well-defined lesions may or may not have a cortex, which may assist in further refinement of the differential diagnosis (Figure 1.32). Although a cortex is, in the majority of cases, strongly suggestive of a benign lesion, be aware that multiple cortices resembling the layers of an onion (Figure 10.14) may suggest not only chronic inflammation but also some malignancies.

A cortex should be distinguished from sclerosis. A cortex is well defined with regard to both the lesion and the normal adjacent bone, whereas the sclerosis is poorly defined with regard to the latter (Figure 1.33).

The effect of the lesion on adjacent structures is expressed by the rule of the Three D's: diameter, density, and displacement; structures such as the mandibular canal can be affected by all three, whereas the cortex and the lamina dura are affected by only density and displacement.

### Diameter

Changes in diameter are best seen in hollow structures such as the mandibular canal and mental and mandibular foramina. If their diameters are increased this suggests that there is a lesion within the structure, whereas if it is decreased the lesion is outside. See Figure 1.7, which displays a narrow mandibular canal invested by *fibrous dysplasia*.
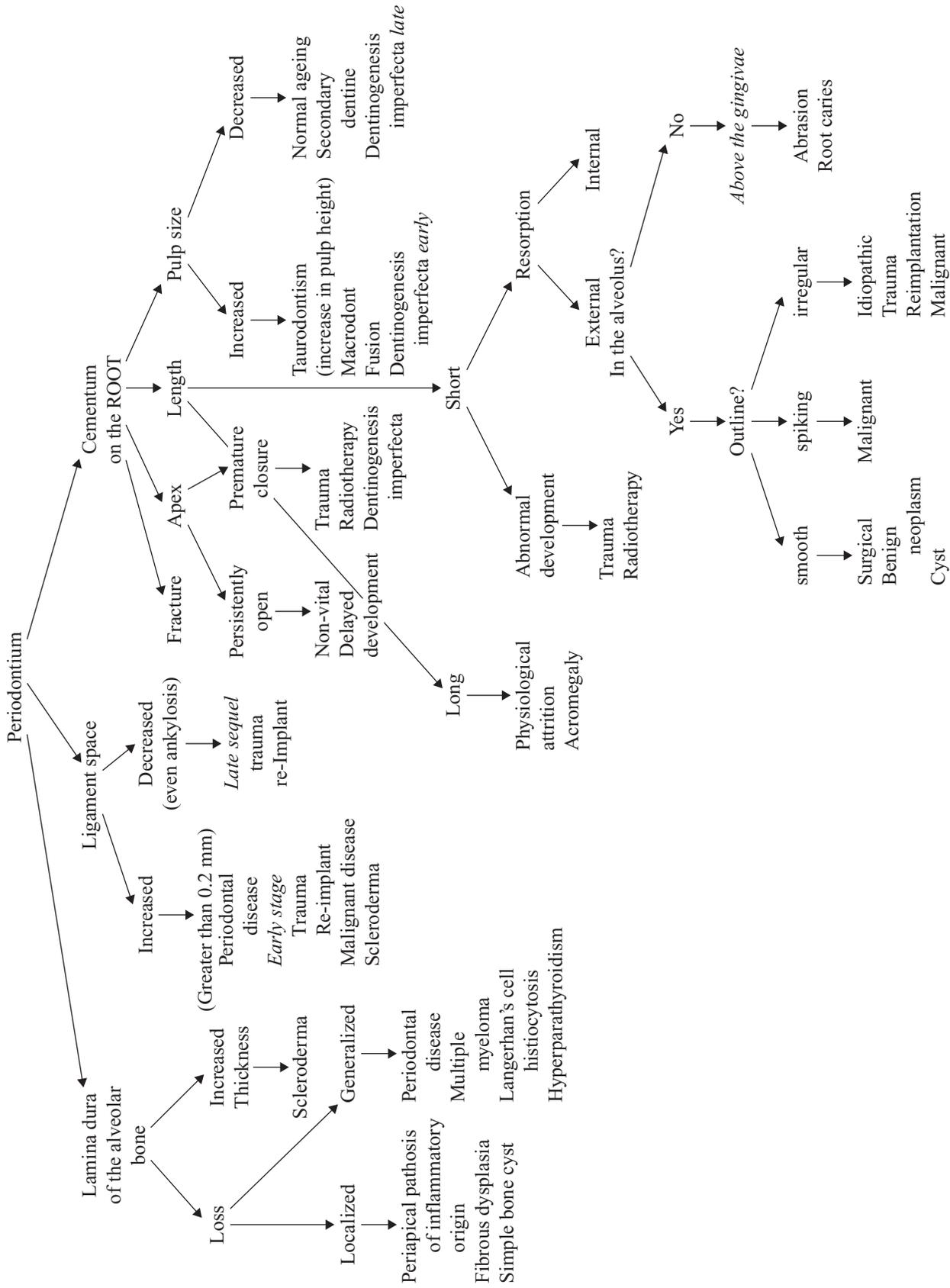
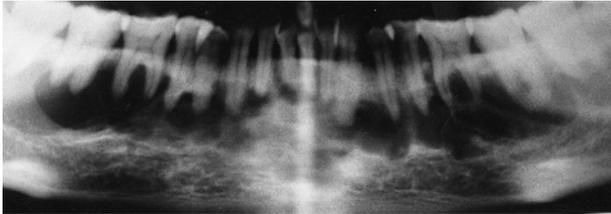**Figure 1.27.** A classification of lesions affecting the periodontium.

**Figure 1.28.** The panoramic radiograph exhibits a well-defined radiolucency, which occupies the entire length of the alveolus. This was a *simple bone cyst*, which arose from four original discrete lesions. Each of these original lesions recurred after surgery and eventually coalesced into one lesion. Reprinted with permission from MacDonald-Jankowski DS. Traumatic bone cysts in the jaws of a Hong Kong Chinese population. *Clinical Radiology* 1995;50: 787–791.



**Figure 1.30.** A periapical radiograph that displays a radiolucency with a well-defined periphery. The lesion has resorbed the roots in line with the bony outline of the lesion. The lesion is a *solid ameloblastoma*.



**Figure 1.29.** Axial computed tomograph (soft-tissue window) displaying a radiolucency within the mandible. The digital measurements are set out at the bottom of the frame. **Note:** Intravenous contrast media has enhanced the blood vessels. The tortuous outline of the lingual artery is observed near the midline anteriorly.



**Figure 1.31.** Panoramic radiograph displaying a poorly defined radiolucency occupying the posterior body of the mandible. There is almost no lamina dura associated with the first molar tooth. There appears to be a thick soft-tissue mass anterior to the vertical ramus. This is a *squamous cell carcinoma*. **Note 1:** The secondary image of the contralateral mandible is superimposed upon the vertical ramus. **Note 2:** The radiolucent region above the tongue represents the residual air-filled space of the oral cavity.
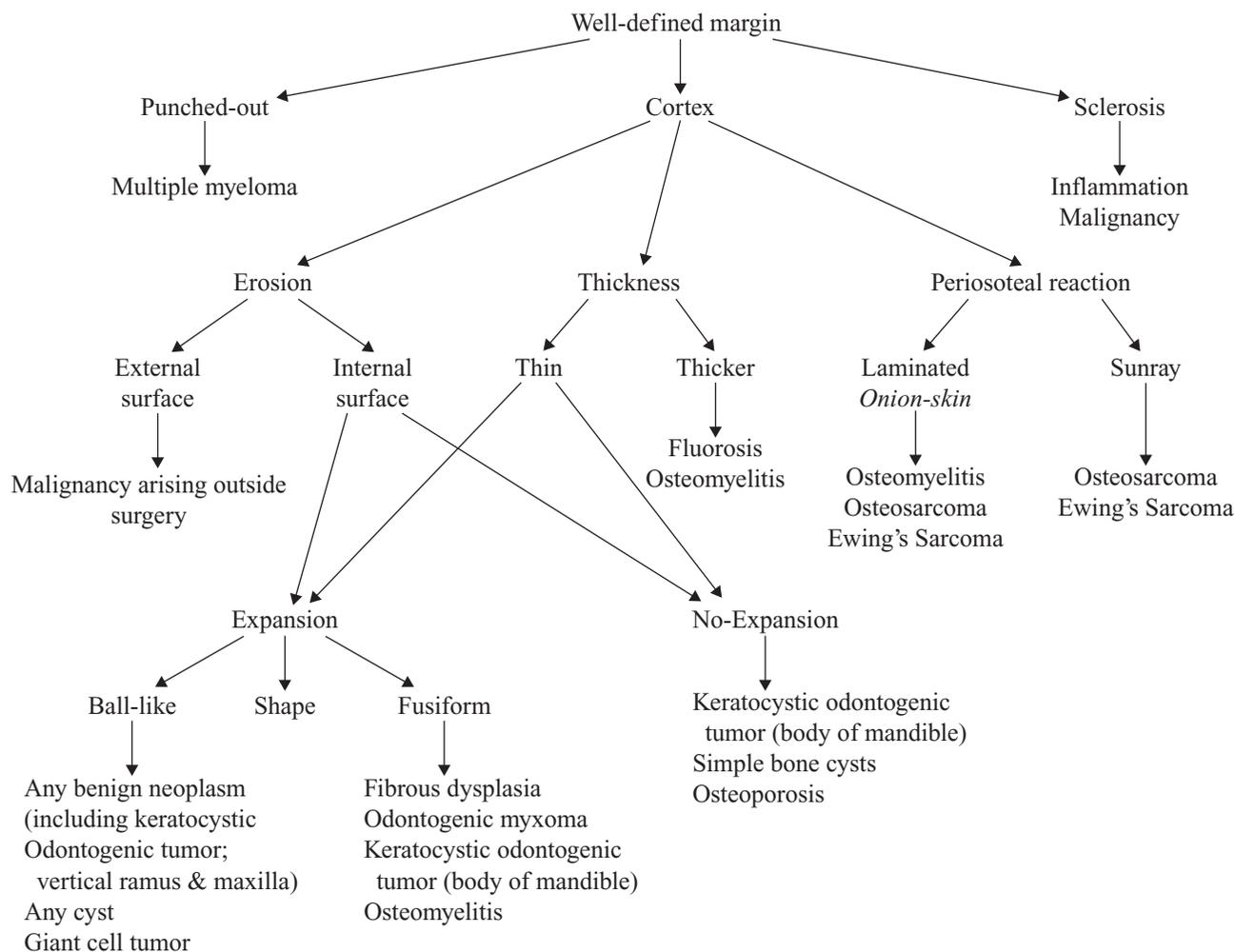
Well-defined margin

Punched-out → Multiple myeloma

Cortex

Sclerosis → Inflammation / Malignancy

Erosion

Thickness

Periosoteal reaction

External surface → Malignancy arising outside surgery

Internal surface

Thin

Thicker → Fluorosis / Osteomyelitis

Laminated *Onion-skin* → Osteomyelitis / Osteosarcoma / Ewing's Sarcoma

Sunray → Osteosarcoma / Ewing's Sarcoma

Expansion

No-Expansion → Keratocystic odontogenic tumor (body of mandible) / Simple bone cysts / Osteoporosis

Ball-like → Any benign neoplasm (including keratocystic Odontogenic tumor; vertical ramus & maxilla) / Any cyst / Giant cell tumor

Shape

Fusiform → Fibrous dysplasia / Odontogenic myxoma / Keratocystic odontogenic tumor (body of mandible) / Osteomyelitis

**Figure 1.32.** Assess the cortex for refinement of the differential diagnosis.

## Density

Changes in density can be observed on teeth, cortices, and hollow structures. A reduction of density on part of a tooth root may suggest resorption either by the lesion or an anatomical structure such as the mandibular canal. Reduction in density of the cortices suggests erosion or even full perforation by the lesion (Figure 1.34). It should be appreciated that much of the radiolucency of a lesion is not derived from the absence of cancellous bone but also erosion, even perforation of either buccal or lingual cortex or both. When the last occurs the lesion's degree of radiolucency is higher and is usually associated with appreciable buccolingual expansion. Perforations of the cortex can occur in several places in the same lesion; if very large, these can give the illusion of multiloculation (Figure 1.35). Always look again for septae before arriving at this conclusion.

Changes in density of the mandibular canal (an increase in translucency-blackening) in association with a lesion or tooth suggest an intimate relationship between them, urging caution during surgery to minimize the risk of damage to the neurovascular bundle it contains. The mandibular canal can appear more translucent (blacker) and thus more conspicuous if the bone is abnormal as evident in the case of *fibrous dysplasia* in Figure 1.7.

Air-filled spaces such as the antrum and the pharynx are visible as radiolucent structure by virtue of their absence of any tissue that could attenuate the X-ray beam; in other words much of
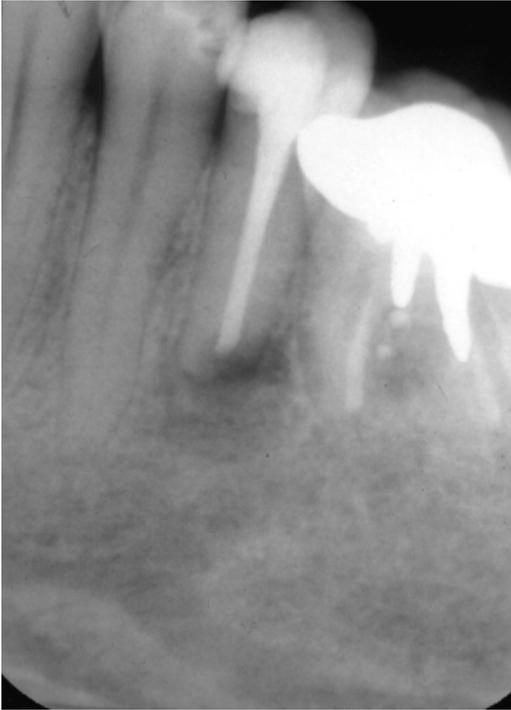
**Figure 1.33.** Periapical radiograph of the mandibular pre-molar region. The mental foramen, mandibular canal, and incisive canal are clearly obvious. Note the upward and backward bend of the canal toward the mental foramen. **Note 1:** The periapical radiolucency associated with the endodontically treated tooth displays root resorption. The radiolucency is well defined, but is not corticated. **Note 2**: The molar, which had also been endodontically treated, exhibits a radiolucency at the furcation. Within this radio-lucency are radiopacities with a similar radiodensity to that of the root-filling material. Therefore, the former are likely to represent extrusion of cement though a perforation of the furcation into the tissues. The well-defined margin of the radiolucency has been enhanced by a zone of sclerosis apical to it.



**Figure 1.34.** This is a oblique lateral projection of the posterior body of the mandible. Note the obliquely super-imposed hyoid bone on the mandible and the contralateral angle of the mandible in the top-right corner. The radiolu-cency is well defined with a thin cortex. It is unilocular. Although the lesion is associated with the cementoenamel junction of the unerupted third molar, suggestive of a den-tigerous cyst, the root resorption of the first and second molars is substantial. The last is more indicative of an ameloblastoma. This is a *unicystic ameloblastoma*. **Note:** The two vertical curved lines in the anterior half of the lesion arise from marked erosions or perforations of either the buccal or lingual cortex. Reprinted with permission from MacDonald-Jankowski DS, Yeung R , Lee KM, Li TK. Ameloblastoma in the Hong Kong Chinese. Part 2: system-atic review and radiological presentation. *Dentomaxillofacial Radiology* 2004;33:141–151.

the beam passing though these structures is rela-tively unattentuated in comparison to the patient imaged. Density changes within are invariably increased densities. In the maxillary antrum this represents both discrete lesions and complete opacification by inflammatory fluid.

### Displacement

The lesion can displace teeth, buccal and lingual cortices (Figure 1.36), the lower border of the man-dible (Figures 1.8 and 1.37) and the antral floor, and the mandibular canal (see Figure 1.8). The types of lesions that most frequently displace adja-cent structures are most benign neoplasms, par-ticularly those with a capsule, and cysts.

## ULTIMATE PURPOSES OF RADIOLOGICAL DIAGNOSIS

For the large majority of patients radiology is central in the treatment planning for caries, peri-odontal disease, and dentofacial disharmony (orthodontics and orthognathic surgery). In addi-tion, radiology is important to
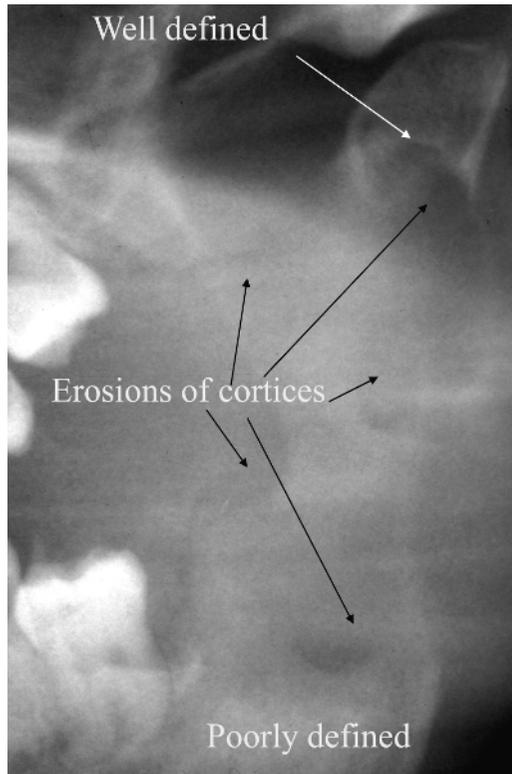
**Figure 1.35.** Panoramic radiograph displaying a radiolucency occupying the vertical ramus. The superior margin at the condyle is well defined, whereas that inferiorly appears poorly defined. The last was caused by the superimposition of the secondary image of the lower border of the contralateral margin upon the lower margin. The Swiss-cheese presentation of the affected vertical ramus reflects the occurrence of more erosions or perforations at certain sites rather than at others. This is a *unicystic ameloblastoma*. Reprinted with permission from MacDonald-Jankowski DS, Yeung R, Lee KM, Li TK. Ameloblastoma in the Hong Kong Chinese. Part 2: systematic review and radiological presentation. *Dentomaxillofacial Radiology* 2004;33:141–151.

1. Distinguish between a malignant and a benign lesion because early diagnosis enhances survival of the former
2. Prompt consideration of locally invasive benign neoplasms so that the most appropriate treatment can be provided to minimize recurrence
3. Prompt consideration of a hemangioma so that the most appropriate treatment plan can be formulated to avoid potential fatal exsanguination.



**Figure 1.36.** A true occlusal projection of the mandible already reviewed in Figure 1.6. There is substantial buccolingual expansion. Both the buccal and the lingual cortex are very thin, particularly buccally. In addition to the distal displacement observed in Figure 1.6. the root of the first premolar has also been displaced buccally. This is a *unicystic ameloblastoma*. Reprinted with permission from MacDonald-Jankowski DS, Yeung R , Lee KM, Li TK. Ameloblastoma in the Hong Kong Chinese. Part 2: systematic review and radiological presentation. *Dentomaxillofacial Radiology* 2004;33:141–151.

## System of Evidence Used in This Textbook

Sackett et al.[10] defined a systematic review as a summary of the medical literature that uses explicit methods to search systematically, appraise critically, and synthesize the world literature on a specific issue. This means that unlike a traditional review the systematic review, like any other form of primary research, will have a "materials and methods" section, and a "results" section.[11]

Systematic review has generally been applied to treatment and drug trials, but has also become a powerful tool when adapted to the clinical and radiological presentations of important oral and maxillofacial lesions.[12–25] These are the ameloblastoma (Figure 1.38),[12–13] odontogenic myxoma

**Figure 1.37.** Panoramic radiograph displaying a *unicystic ameloblastoma* associated with the third molar (this attachment is apical to the cementoenamel junction). The second molar's roots appear to have been displaced anteriorly. The lowest border of the lesion has expanded down past the still undisplaced and largely intact lower border of the mandible. Although this phenomenon is generally a feature of the ameloblastoma, it has also been observed for ortho-keratinized odontogenic cysts. **Note 1:** The secondary image of the contralateral mandible has conferred a ground-glasslike appearance on the upper two-thirds of the lesion. The lower third displays a truer degree of radiodensity. **Note 2:** The erupting maxillary third molar exhibits an enlarged follicular space.
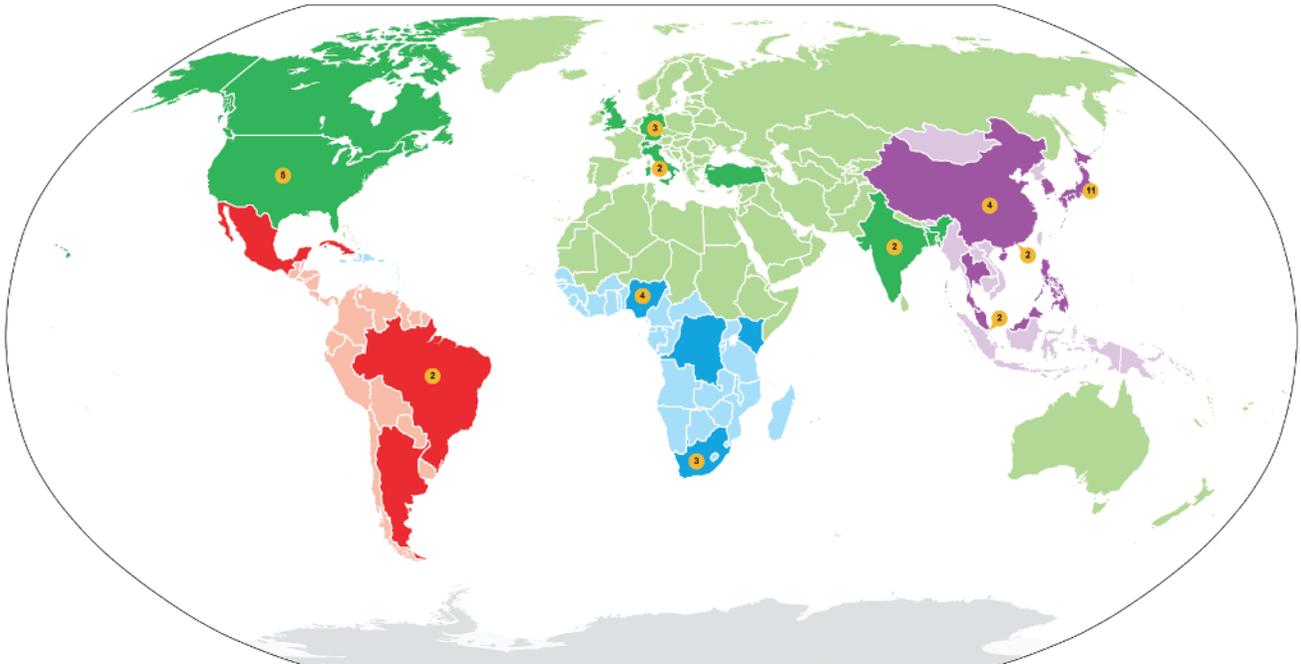


**Figure 1.38.** Ameloblastoma: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
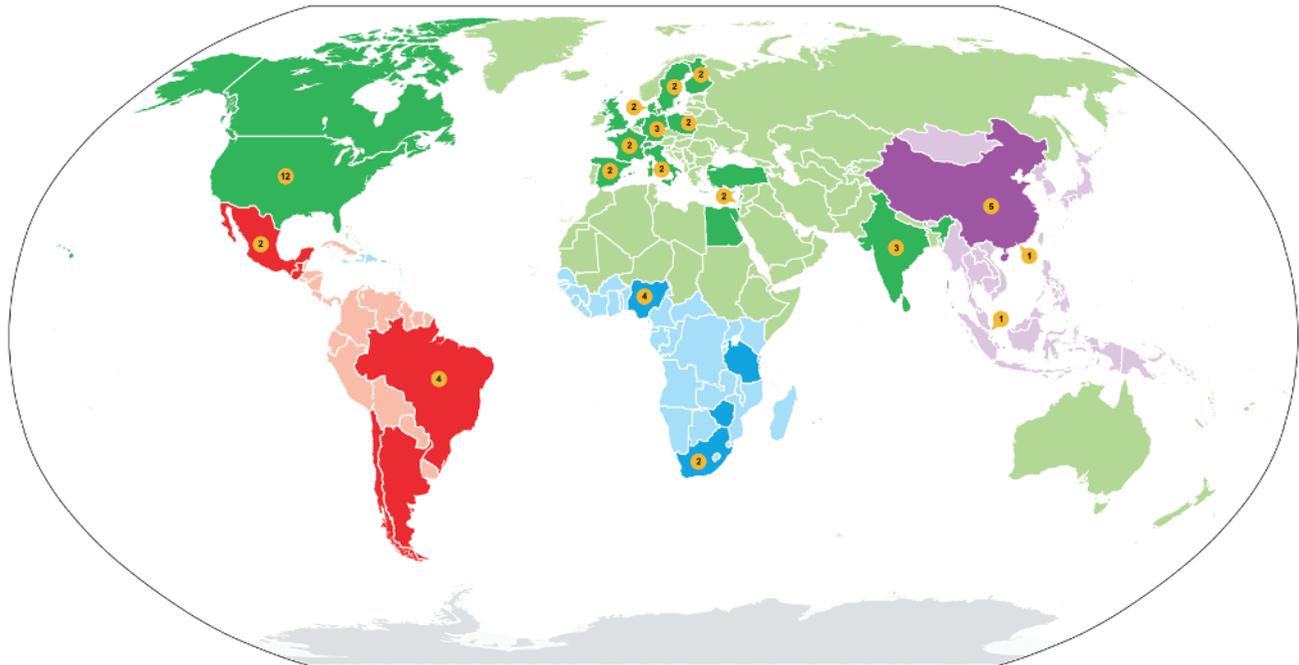
**Figure 1.39.** Odontogenic myxoma (updated March 2010): global distribution of those reports included in the systematic review. Note that both Swedish reports are binational: 1 with Denmark and 1 with Finland. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.

(Figure 1.39),[14] keratocystic odontogenic tumor (Figure 1.40),[15] dentigerous cyst (Figure 1.41),[16] orthokeratinized odontogenic cyst (Figure 1.42),[17] glandular odontogenic cyst (Figure 1.43),[18] fibrous dysplasia (Figure 1. 44),[19] ossifying fibroma (Figure 1.45),[20] florid osseous dyplasia (Figure 1.46),[21] Focal osseous dysplasia (Figure 1.47),[22] idiopathic osteosclerosis (Figure 1.48),[23] central giant cell granuloma,[24] and cleidocranial dysostosis.[25]

## Global Groups

In order to determine deeper patterns within the systematic review, its reports are divided into four Global groups based broadly on ethnicity; these are East Asian (predominantly represented in the SR by Chinese and Japanese), sub-Saharan African (predominantly Black Africa, including Jamaica), Western/Caucasian (North America and Europe, Middle East, North Africa, and India), and Latin American (including Cuba). Although the Western group is predominantly White (Caucasian; classically of European origin) it contains significant non-White minorities, particularly from sub-Saharan Africa. The population of the United States was at the last census 69.1% White.[26] Reports from the Indian subcontinent are included in the Western/Caucasian group, because 95% of Indians are Caucasian (Indo-Aryans and Dravidians). Although these four global groups are cartographically represented by four almost discrete regions, they are not primarily regional, because variable socioeconomic and other ethnocultural factors also play important roles that affect the availability and provision of diagnostic and therapeutic services. For example, the South Asian nations, including India, although largely Caucasian nations, are still developing their economies, along with many of those of sub-Saharan Africa. Although Africa itself is divided between a Caucasian North and a substantially Black sub-Saharan South, it is the latter that constitutes both the bulk of the population of the African continent and the African diaspora (Jamaica is 90%
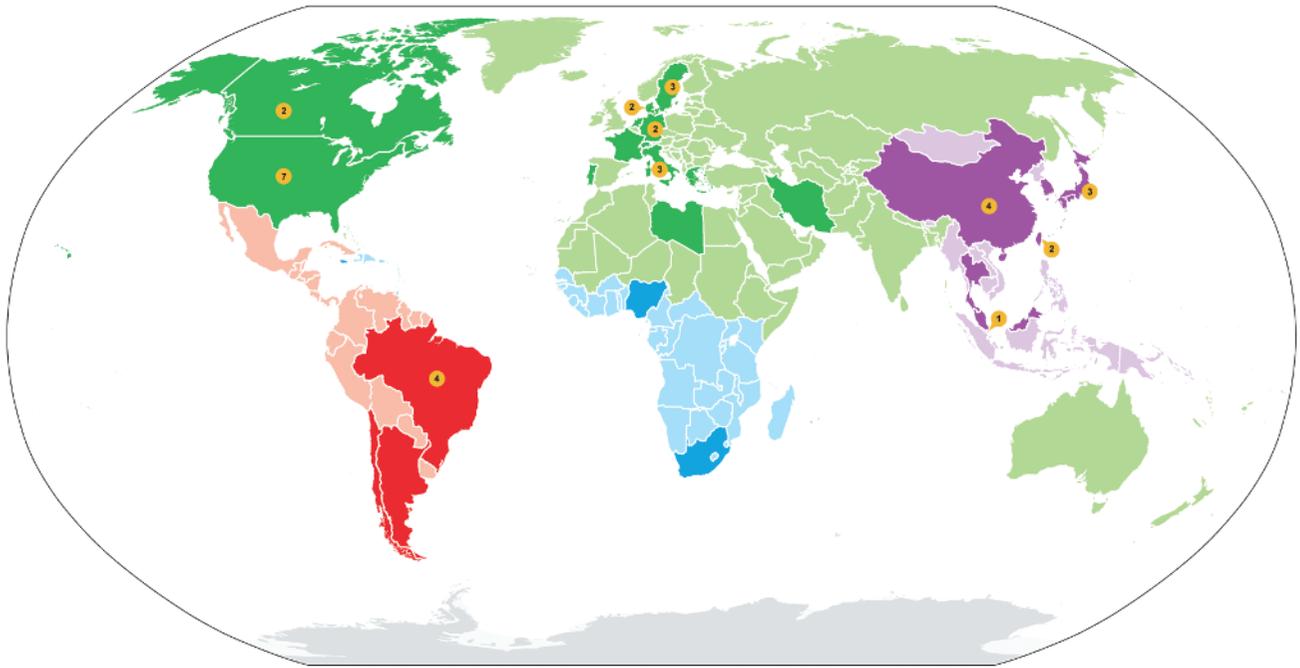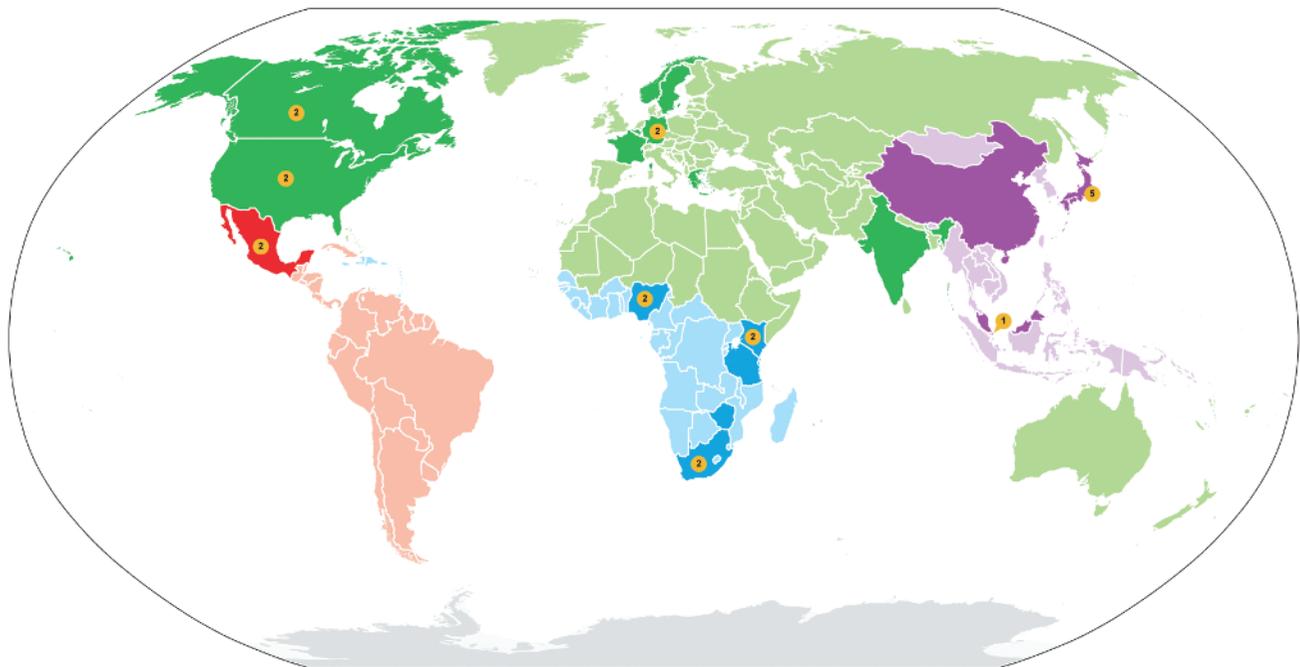
**Figure 1.40.** Keratocystic odontogenic tumor: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
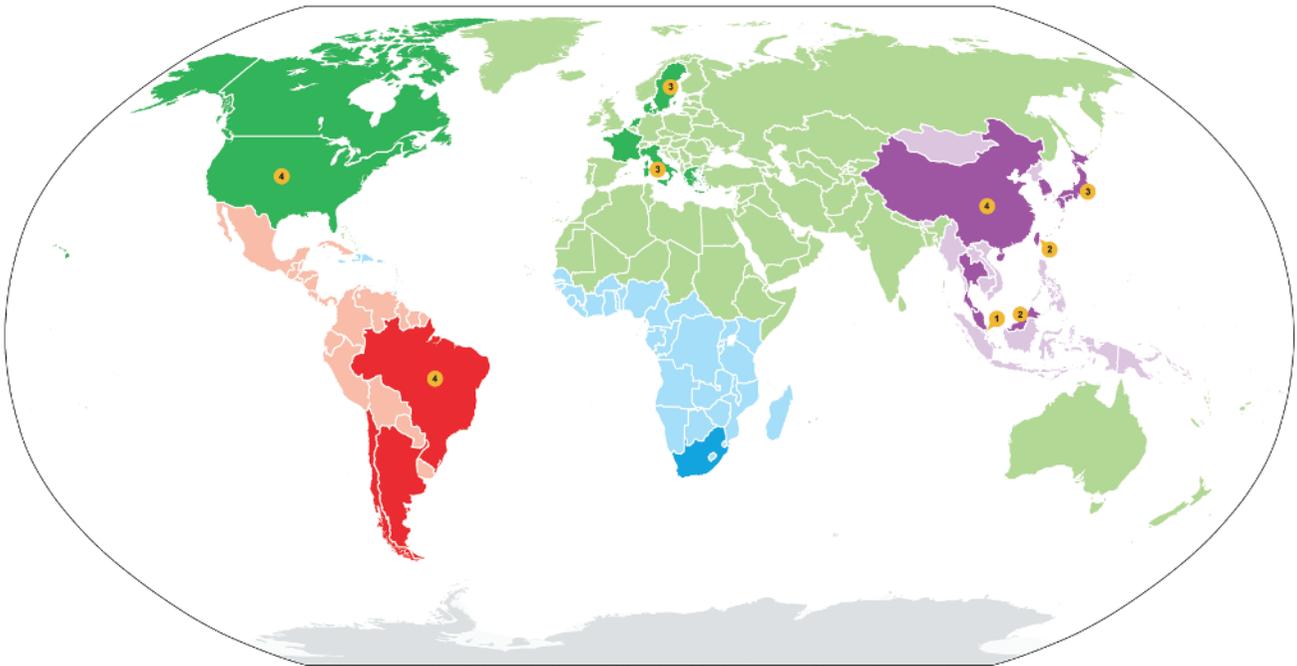


**Figure 1.41.** Dentigerous cyst: global distribution of those reports included in the Systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
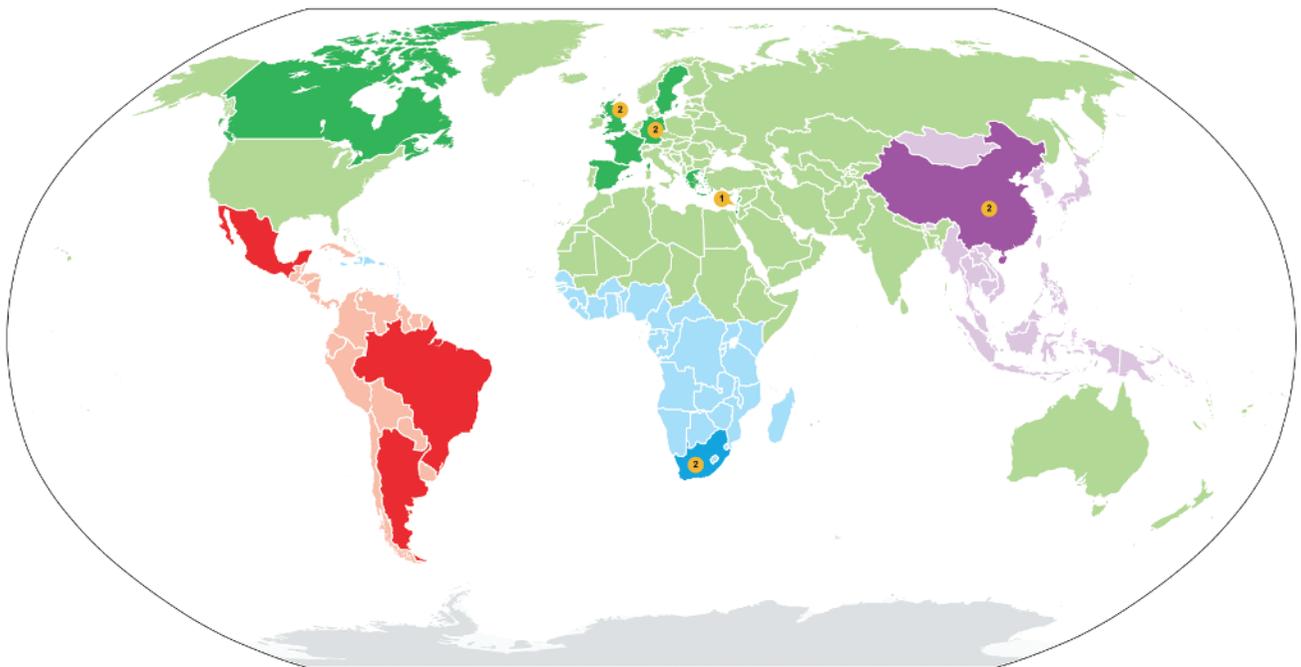
**Figure 1.42.** Orthokeratinized odontogenic cyst: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
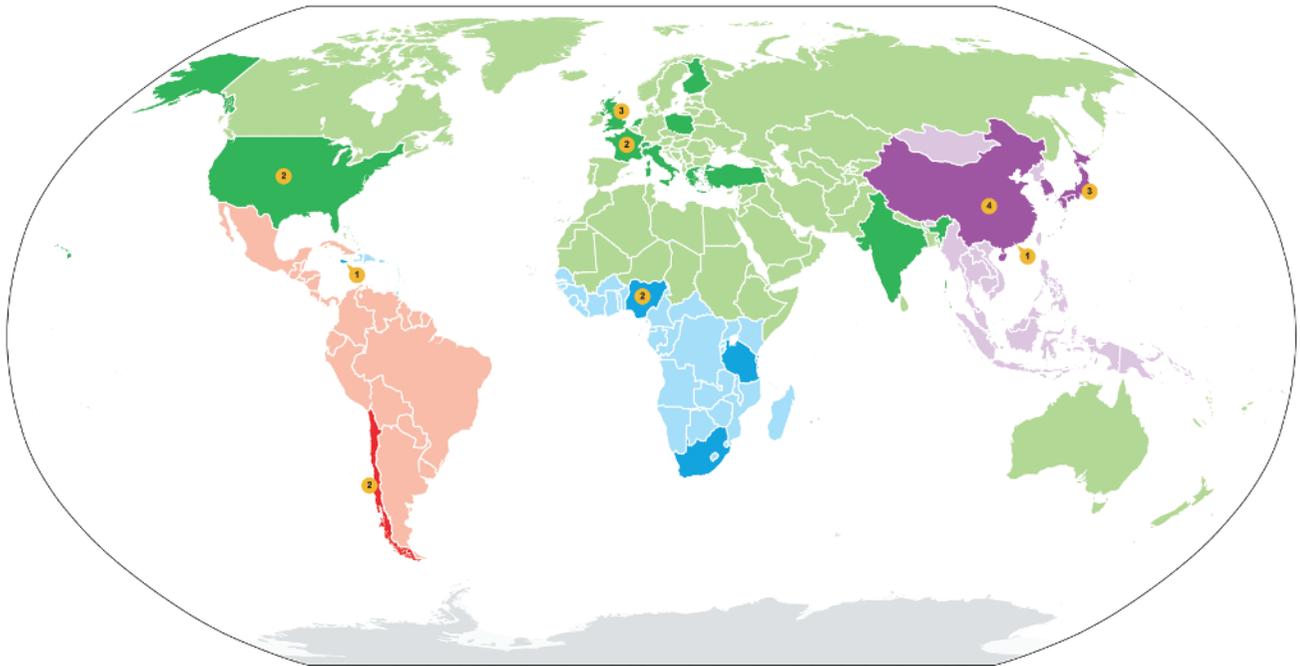


**Figure 1.43.** Glandular odontogenic cyst: global distribution of those reports included in the systematic review Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
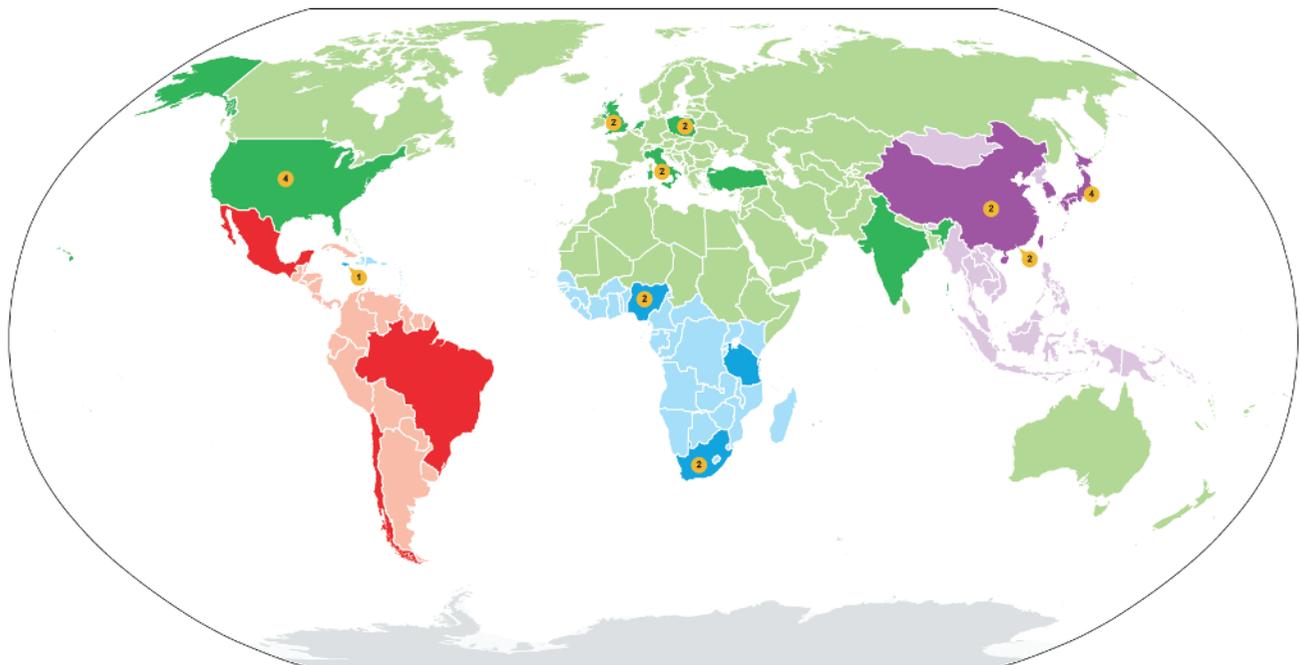
**Figure 1.44.** Fibrous dysplasia: global distribution of those reports included in the Systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.



**Figure 1.45.** Ossifying fibroma: global distribution of those reports included in the Systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
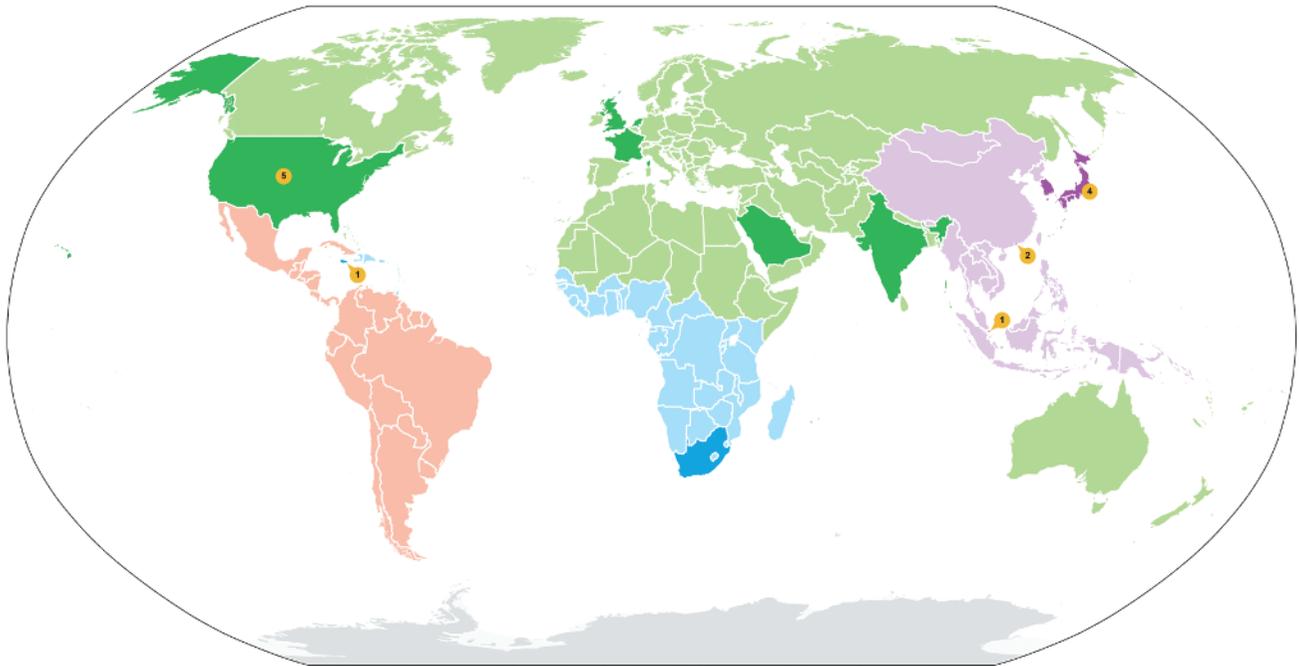
**Figure 1.46.** Florid osseous dysplasia: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
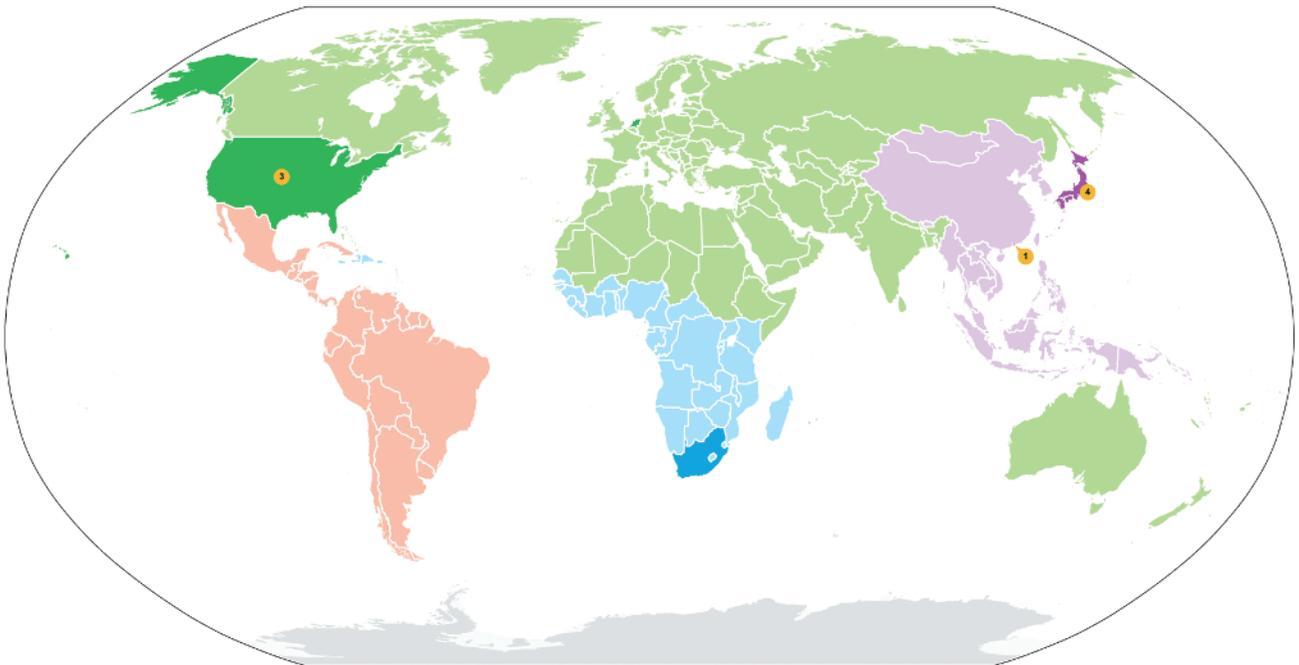


**Figure 1.47.** Focal osseous dysplasia: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.
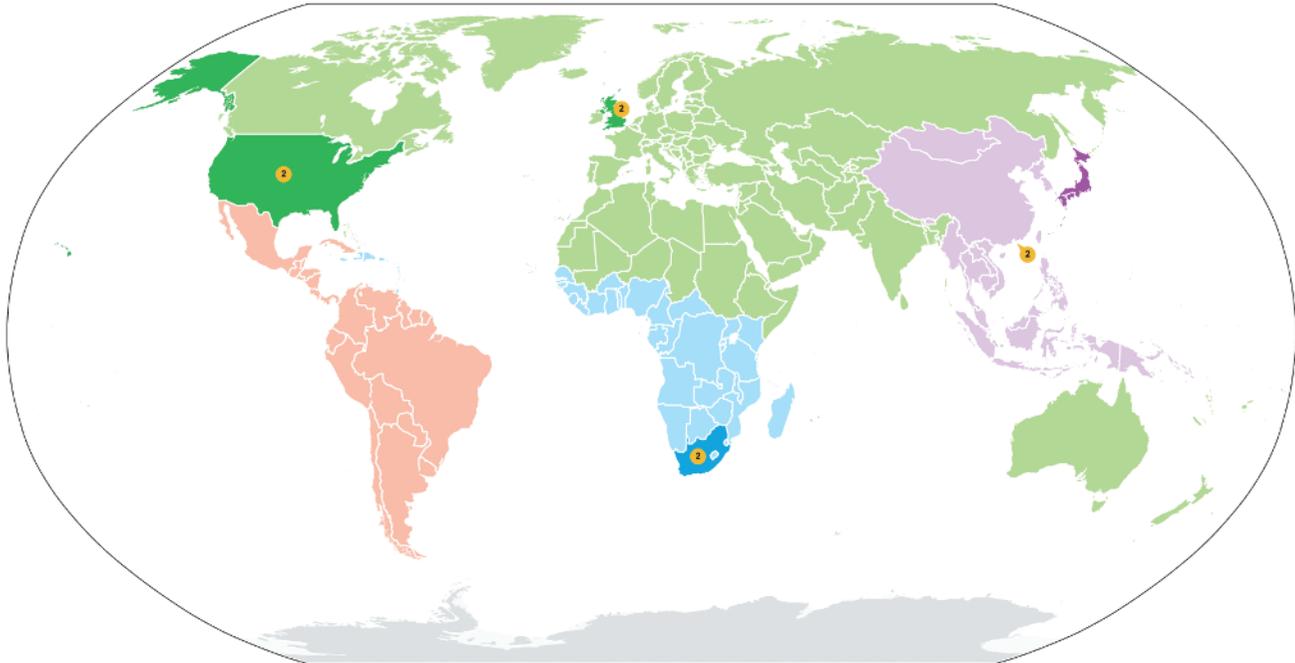
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**Figure 1.48.** Idiopathic osteosclerosis: global distribution of those reports included in the systematic review. Green for Western or predominantly Caucasian communities, blue for sub-Saharan African communities, violet for East Asian communities, and red for Latin American communities. The lighter shades denote each of the four global groups or regions, whereas the darker shade denotes a systematic review-included report for a particular state. If more than one such report exists, the number over one is inserted for that state. Acknowledgment: James Pagnotta: Media support analyst: Faculty of Dentistry; University of British Columbia.

of sub-Saharan African origin). Although the global distribution for each lesion is largely determined by the number size and quality of the systematic review-included reports, the lesions for some communities are likely to be underreported. These are discussed in Chapters 9 and 10.

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